Gamifying Fitness or Fitnessifying Games: a Comparative Study

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Abstract

Fitness- or exergames are ubiquitously available, but often lack the main ingredient of successfully gamified systems: fun. This can be attributed to the typical way of designing such games – highly focusing on specific physical activities, thus, *gamifying fitness*. Instead, we propose a novel alternate approach to improve motivation for exergaming, which we call *fitnessification*: integrating physical exercise into very popular games that have been developed keeping fun in mind and frequently are played for long periods of time – so-called *AAA games*. In order to evaluate this concept, we have conducted a comparative study examining voluntary participants' reactions to testing an ergometer controlled casual game as well as a modified AAA game. Results indicate strong tendencies of players preferring the newly introduced AAA approach over the casual fitness game.

1 Introduction

"*Technology brings you great gifts with one hand, and it stabs you in the back with the other.*"[1] – British scientist Charles Percy Snow in his comment to The New York Times addresses a common dilemma in modern society. Technology regularly is associated with *convenience* because it is able to facilitate and improve many aspects of our lives: smartphones with internet access replace tangible city maps, on-demand video streaming gives people the option to watch movies at home rather than having to visit a theater and action-packed computer games are way more fun than playing jump-rope outside. These "advantages" over the past, however, frequently entail grave detrimental effects: social isolation [MSLB06], cognitive laziness [Car08] and physical inactivity [KHKI+05] have been reported to affect many people's lives, the latter even being deemed the biggest public health problem of the 21st century [Bla09].

Despite current trends, exercising to many individuals yet is desirable and oftentimes all it takes to get a person started is the right kind of motivation – something ironically *technology* in combination with a special kind of *gamification*[2] can provide [WH12]: rather than using specific game design elements to encourage sportive activities, as is commonly done in various fitness apps and devices, it is possible to employ full-blown video games that interact with fitness accessories, a popular concept pursued by all major gaming consoles as well as arcade machine manufacturers.

By now such *exergames* are ubiquitously available and their substantial estimated market share of over 6.6 billion dollars highlights a general public interest in purchasing them [DGL08]. However, in spite of those facts, the buyers' initial excitement often quickly fades and widely promoted beneficial effects like changing peoples' physical exercise habits are limited to a short period of time, after which the games are shelved[3], making room for new, more exciting games. Several studies underline that notion of rapidly declining interest [BAB+12, LML+06, MLB13], emphasizing that ultimately fun plays a vital role in any game – a game

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[1]Quote first appeared in The New York Times, 15 March 1971.

[2]For our purposes we define gamification based on Werbach/Deterding and colleagues' definitions [WH12, DDKN11], as *the use of game elements and game-design techniques in non-game contexts to solve problems and engage users.*

[3]Michael Rosenberg for The Conversation, 2014: "Sorry gamers, Wii Fit is no substitute for real exercise" (http://tinyurl.com/pzyopx8, Web. 29 Jun. 2016)

lacking fun just turns into a plain task. The root of this problem becomes apparent when regarding the intuitive but naive design approach for a fitness game: gamifying sports strongly advocates a focus on physical activity – fun games, however, are not really fixated on anything other than bringing joy and satisfaction to their players. Therefore, a much more interesting approach is to shift said focus onto popular games and enhancing *them* with fitness elements, i.e. applying what we call *fitnessification*.

A broad category of such popular games is comprised of so-called *AAA games* (pronounced 'triple-A games'), which generally are created by big companies often investing huge amounts of money in their development. Compared to current fitness games they do a much better job at entertaining players, as they often bear high replay values, feature the latest advanced technologies and are generally designed much more thoughtfully. Good AAA games maintain their popularity for long periods of time and sometimes even are played for decades[4], while enjoying an active and vibrant community of fans. Accordingly, they usually are referred to as the most attractive and anticipated games on the market.

This work should be regarded as an impulse to support the notion of integrating fitness elements into such fun games and, thereby, increasing the motivation for exergaming. For this purpose we have conducted two comparable field studies as a way of proofing our novel concept of fitnessification: an off-the-shelf ergometer has been utilized to control a purpose-built casual and a modified AAA game prototype – Flappy Cycling (FC) versus Quake 3 Arena Fitness Edition (Q3AFE). After trying out these games voluntary participants conveyed their opinions towards sports, gaming, exergaming and the tested prototypes via identical questionnaires for both examinations. Our contributions include:

- Study overview and research goals (Section 2)
- Exergames and their architecture (Section 3)
- Hybrid evaluation results (Section 4)
- Related work (Section 5)
- Conclusions and further work (Section 6)

2 Study Overview

The studies have been set up on two different occasions in the same public location, the aula of the Alpen-Adria University (AAU). Both involved user experience analyses were kept as similar as possible: in a supervised field study, voluntary passers-by were given sufficient instructions to be able to try out the finished projects for as long as they liked with a nonbindung suggestion of five minutes and in immediate succession were asked to fill out an anonymized questionnaire about their experiences, which took place on-site but unsupervised (see Section 4.1 for more details about the surveys). Each of the studies has been preceded by preliminary trial runs, where students and colleagues have tested the respective prototype and gave valuable feedback, which helped improving it prior to the actual examination.

2.1 Research Goals

The main purpose of this work is to show that fitness-enhanced AAA games are more enjoyable than games specifically designed for supporting physical exercise. Hence, the central evaluation statement **S** can be summarized as follows:

S Fitnessification of games encourages more positive feedback than gamification of sports.

Based on this goal, several research questions can be developed, summarizing the purpose of this thesis as well as related future aspects:

Q1 How do sportive/unsportive people feel about exergaming?
Q2 Can exergaming be more fun?
Q3 Given the AAA game integration, would it be possible to motivate people to work out more?
Q4 Which conditions must be satisfied for gamers to consider exergaming at home?

Several hypotheses have been developed based on above questions, listed in Section 4.2.

3 Architecture and Games

From a hardware point of view, a fitness device needs to be suitably connected to a computer and the architecture approach taken is depicted in Figure 3.

As mentioned in the Introduction, an ergometer[5] has been used as a sports device in both studies, providing two kinds of data – the cycling rate and pulse sensor information via two attached handles. To be able to properly capture signals from the device, an *Arduino Leonardo*[6] was used, which is a powerful, programmable open-source microcontroller board. Additionally, a separate pulse sensor[7] was employed, as to

[4] E.g. "Counter-Strike" (Valve Corporation, 1999: `http://tinyurl.com/ccat4e`, Web. 29 Jun. 2016) and "World of Warcraft" (Blizzard Entertainment, 2004: `http://tinyurl.com/39vdalk`, Web. 29 Jun. 2016)

[5] Model: Ultrasport F-Bike 150/200B (`http://tinyurl.com/jlqnbna`, Web. 29 Jun. 2016).

[6] Product information page: `http://tinyurl.com/qc2xzda`, Web. 29 Jun. 2016.

[7] Made by *World Famous Electronics* (`http://pulsesensor.com`, Web. 29 Jun. 2016).

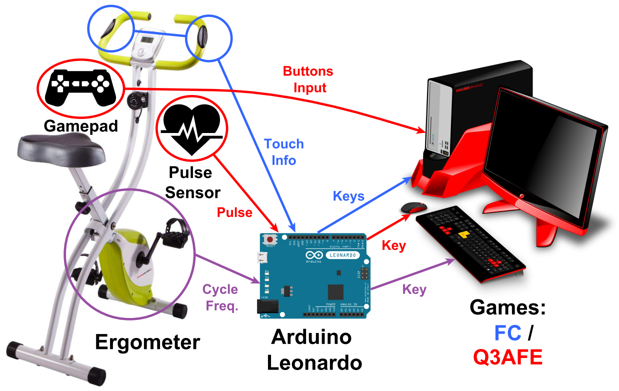

Fig. 1: HW Architecture for FC, Q3AFE and both.

enable controlling a game with a joystick while measuring the user's heart rate through merely applying a finger strap (see Section 3.2). Fitness input used for both games is colored in violet, while FC only elements are marked blue and Q3AFE components are shown in red. Every signal is translated into keypresses by the Arduino, serving as input commands to the games described in following sections.

3.1 Flappy Cycling (FC)

Flappy Cycling is inspired by unexpected smash hit casual game Flappy Bird[8] and has been implemented from scratch using popular HTML5 game developer's framework Phaser[9]. Flappy Bird is essentially a smartphone-based endless side-scroller, giving players control over a bird, which flies through a horizontally scrolling scene and must avoid hitting randomly appearing green obstacle pipes. Tapping the screen gives the animal an upward boost, refraining to do so lets simulated gravity take its course. Flappy Cycling builds on this idea by boosting the bird's vertical screen position on every fully completed pedal cycle and instead of dodging randomly appearing static objects players must evade enemy birds flying towards them in wavy patterns. This can be achieved via touching the ergometer's pulse sensor handles, which were diverted from the intended use in order to merely detecting whether someone is touching either of them, enabling the controlled bird to horizontally fly forwards and backwards. A player's high-score is calculated by gradually increasing a point multiplier over time, which is reset every time an enemy bird is hit or the bird leaves the middle third of the screen on the vertical axis. The goal is to rack up as many points as possible within a five-minute time limit, while the amount and speed of enemies constantly increases.

[8]Developed by Dong Nguyen and deemed most addicting mobile games of 2013 (`http://tinyurl.com/z6sls4s`, Web. 29 Jun. 2016).
[9]Phaser HTML5 framework (`http://phaser.io`, Web. 29 Jun. 2016)

This prototype represents the conventional way of designing an exergame – building it around the fitness activity.

3.2 Quake 3 Arena Fitness Edition (Q3AFE)

Quake 3 Arena (Q3A) is the third installment of the popular Quake series[10], which included first-person shooters (FPS) that have been among the first games featuring true real-time 3D game engines, released by id Software[11] in 1999. The series achieved tremendous success and even nowadays Q3A still is a popular title, particularly on so-called *LAN parties*, where players get together, establish local connections with their PCs and hunt each other down in virtual *deathmatches* with the goal of eliminating as many opponents as possible, i.e. scoring kills or *frags*. This AAA game has been chosen for applying fitnessification because back in the 1990s the series' developers picked up on a newly emerging trend, which they wholeheartedly supported in Q3A: game *modding*, i.e. modifying popular games in terms of visuals, mechanics or gameplay. Q3As engine is constructed in a modular manner and parts of it can easily be replaced by customized dynamic-link libraries (DLLs). Thus, standard gameplay could comfortably be adjusted to incorporate user-generated fitness information for our study. Q3A basically is a multi-player game but also features a single player mode, which has been a requirement for the resulting (Q3AFE) modification (*mod*) in order to be comparable to FC. In this mode, the player's opponents, so-called *bots*, are controlled by the computer via an artificial intelligence (AI) library.

A typical deathmatch begins by randomly putting the player as well as all bots on distinct starting spots set throughout a virtual level (*map*), which is called *spawning*. Newly spawned players have a distinct amount of health points (HP) and some starting weapons. The goal is to win a tournament by being the first to kill a previously set amount of opponents (*frag limit*). Being killed by an enemy triggers a *respawn*, again at a random location. Throughout the game, weapons and *power-ups*, boosting a player's abilities, can be acquired, all of which are scattered throughout the map and as well constantly respawn after small timeouts when picked up by players. Study participants played one such scenario, while being rewarded for performing well on the ergometer.

Compared to FC, a lot more buttons are needed to control Q3AFE: walking forwards, backwards or sideways, looking around (panning the camera), jumping, ducking, shooting, switching weapons, zooming

[10]Quake series on Steam: `http://store.steampowered.com/sub/434`, Web. 29 Jun. 2016.
[11]`http://www.idsoftware.com`, Web. 29 Jun. 2016

and even more. Therefore, an additional input possibility has been employed: a common gamepad directly plugged into the PC. Holding such a game controller, in turn, renders the ergometer's pulse handles useless, as touching them requires letting go of the gamepad, which would be fatal in a fast-paced FPS like Q3A. Since the pedals then would be the sole remaining means of capturing fitness input, a finger-attachable pulse sensor has been added as well. Altogether, the ergometer pedals controlled the speed of the player and users were rewarded with in-game power-ups, when staying in a previously selectable heart rate zone (`recovery`, `aerobic`, `anaerobic`).

4 Evaluations

A hybrid approach including a qualitative (Section 4.3) and quantitative analysis (Section 4.4) has been chosen for evaluating the collected survey data, consisting of altogether 33 (FC) plus 34 (Q3AFE) records. Before outlining discovered results, Section 4.1 describes the essence of the questionnaire and subsequent Section 4.2 lists hypotheses formulated prior as well as after carrying out the studies, the latter resulting from conducting a variable correlation analysis.

4.1 Questionnaire

In general, the questionnaire can be grouped into five categories: demographic data (`general`), user habits and opinions (`sports`, `gaming` & their `combination`) and `prototype` specific questions. For the quantitative analysis, response statistics, as well as answers optionally entered into several free text boxes, have been examined. A total of 23 relevant variables can be defined out of the survey questions, a listing of which, however, would go well beyond the scope of this paper. Variables either are of ordinal (5-valued tendency scale) or dichotomous (bi-valued) nature: for any quantitative analysis two selected datasets (usually $A_{\subseteq FC}$ and $B_{\subseteq Q3AFE}$) either were partitioned by an existing dichotomous variable or via bisecting responses for an ordinal scale variable. Afterwards another ordinal variable has been used to evaluate tendencies in both resulting groups.

4.2 Hypotheses

Six hypotheses (H1-H6) have been developed prior to conducting the studies and seven (H7-H13) resulted from post-study analysis of variable correlation coefficients: ϕ-coefficient [Cra45] for two dichotomous features, Kendall rank correlation with tie correction [Ken38, Ken48] for ordinal data comparison and the rank-biserial correlation [Cur56] for pairs of both variable types.

H1 Gamers would rather play AAA exergames than casual exergames at home ($A_{\subseteq FC} < B_{\subseteq Q3AFE}$).

H2 Active[12] people would rather play AAA exergames than casual exergames at home ($A_{\subseteq FC} < B_{\subseteq Q3AFE}$).

H3 Regular gamers who are less active would rather consider working out more playing AAA exergames than casual exergames ($A_{\subseteq FC} < B_{\subseteq Q3AFE}$).

H4 Active people would rather play exergames at home than rarely active people (H4$_a$: $A_{1\subseteq FC} < B_{1\subseteq FC}$, H4$_b$: $A_{2\subseteq Q3AFE} < B_{2\subseteq Q3AFE}$).

H5 Less active people would rather consider working out more by playing exergames than regularly active persons (H5$_a$: $A_{1\subseteq FC} > B_{1\subseteq FC}$, H5$_b$: $A_{2\subseteq Q3AFE} > B_{2\subseteq Q3AFE}$).

H6 Regularly active occasional gamers would rather play AAA exergames than casual exergames at home ($A_{\subseteq Q3AFE} > B_{\subseteq FC}$).

H7 Regularly active people would rather consider working out more playing AAA exergames than casual exergames ($A_{\subseteq FC} < B_{\subseteq Q3AFE}$).

H8 Cyclists would rather consider playing AAA exergames than casual exergames ($A_{\subseteq FC} < B_{\subseteq Q3AFE}$).

H9 Students/gamers/all participants enjoy playing AAA exergames more than they do playing casual exergames (H9$_a$: $A_{2\subseteq FC} < B_{2\subseteq Q3AFE}$, H9$_b$: $A_{1\subseteq FC} < B_{1\subseteq Q3AFE}$, H9$_c$: $A_{3\subseteq FC} < B_{3\subseteq Q3AFE}$).

H10 Gamers/all participants have better experience with the ergometer when playing a AAA exergame instead of a casual exergame ($A_{\subseteq FC} < B_{\subseteq Q3AFE}$).

H11 Lower ergometer experience influences overall experience negatively (H11$_a$: $A_{1\subseteq FC} < B_{1\subseteq FC}$, H11$_b$: $A_{2\subseteq Q3AFE} < B_{2\subseteq Q3AFE}$).

H12 Regular Gamers rate AAA exergames higher than casual exergames ($A_{\subseteq FC} < B_{\subseteq Q3AFE}$).

H13 Less regular active people are less comfortable handling the ergometer than regularly active persons (H13$_a$: $A_{1\subseteq FC} < B_{1\subseteq FC}$, H13$_b$: $A_{2\subseteq Q3AFE} < B_{2\subseteq Q3AFE}$).

4.3 Qualitative Analysis

Collected data for `general` type questions for both studies reveals a predominant male participation ($>$ 70%). Therefore, conducting any gender-specific analyses on the accumulated records would not be feasible. The average specified ages range from 25 to 30 and in particular, almost all participants were below 35 years old with altogether five exceptions. Close to half of the volunteers, in equal proportions for both

[12] Active refers to practicing sports in all hypotheses.

studies, were students and the majority of the remaining people were employed in a technical field. This is expectable, since study setups, such as the ones conducted for this thesis, especially appeal to people interested in technology. Despite the AAU's multicultural student base[13], most of the test subjects have been from Austria (FC: 76%, Q3A: 70%) and in general, almost all participants were from Europe with two exceptions.

When regarding the gathered study-specific statistics, both studies influenced user experience positively as well as negatively, although Q3AFE seems to have been better accepted. The reason both experiments overall received fairly high ratings could be due to their novelty effect: in both cases, only 15% claimed to have partaken in similar studies and comparable home devices are still rare. Nevertheless, the biggest issues reported were control-specific, i.e. difficulties with FC's pulse handles and Q3AFE's use of a gamepad instead of keyboard/mouse, which in future versions should be improved as to prevent any biased opinions caused by these inconveniences. Furthermore, the most important future aspect should be testing long-term user engagement in playing these games. Outcomes for such experiments probably depend on how regularly users play games, but judging by several user remarks FC might not perform as well as Q3AFE: "*Game seems a bit random.*" (FC), "*It is a fun game, but I think it will get boring after a while.*" (FC).

4.4 Quantitative Analysis

Most of the questions prompted the users to rate an aspect on a 5-valued ordinal scale, which overall did not yield normally distributed results, as is mostly the case when employing variables not describing intervals [Sca13]. Therefore, analogous to previously listed correlation coefficients, a non-parametric evaluation method has been chosen for all hypothesis evaluations: the Mann-Whitney-Wilcoxon (MWW) test [Wil47] with significance $\alpha = 0.05$. The collective results are listed in Table 1, pointing out for which hypotheses H_0 can be rejected on significance levels of up to $\alpha = 0.10$.

The MWW test is used to determine if two populations (A, B) differ in their distributions, i.e. the assumed null hypothesis H_0: $A = B$ can be rejected in favor of an alternative hypothesis H_1: $A \neq B$, $A < B$ or $A > B$. It accomplishes this by ranking the elements of both sample sets (lower value are assigned smaller ranks), summing up those ranks for both sets (tied ranks are averaged) and computing the difference in rankings (U-value). It assumes an approximate normal distribution of U-values to be able to make use of

[13] cf. AAU report 2015/16 (`http://tinyurl.com/jqq2c7h`).

Tab. 1: Hypotheses MWW Evaluations. Set partitions: A & B, MWW p-value: p, test statistic: z, MWW observed U-value: u, U-value std. error: σ_u.

H_1	$\|A\|$	$\|B\|$	p	z	u	σ_u	reject H_0
H1	16	21	0.038	-1.774	118	168	for $\alpha = 0.05$
H2	23	23	0.087	-1.360	211.5	264.5	for $\alpha = 0.10$
H3	4	10	0.243	-0.698	17	20	no
$H4_a$	5	19	0.349	-0.388	43	47.5	no
$H4_b$	9	16	0.437	-0.159	69.5	72	no
$H5_a$	13	11	0.057	1.581	50	71.5	no ($U_{\alpha=0.10} < u$)
$H5_b$	17	8	0.089	1.344	55	68	no ($U_{\alpha=0.10} < u$)
H6	3	8	0.882	-1.186	7.5	12	no
H7	11	8	0.187	-0.888	35	44	no
H8	20	10	0.171	-0.952	85	100	no
$H9_a$	15	14	0.001	-2.980	42	105	for $\alpha = 0.01$
$H9_b$	22	27	0.030	-1.880	219.5	297	for $\alpha = 0.01$ ($u < U_{\alpha=0.01}$)
$H9_c$	33	34	0.006	-2.500	385.5	561	for $\alpha = 0.01$
H10	22	27	0.003	-3.481	140.5	297	for $\alpha = 0.01$
$H11_a$	21	12	0.145	-1.058	101	126	no
$H11_b$	8	26	0.010	-2.320	54.5	104	for $\alpha = 0.01$
H12	9	16	0.167	-0.967	56.5	72	no
$H13_a$	17	16	0.051	-1.639	96	136	for $\alpha = 0.10$
$H13_b$	23	11	0.179	-0.918	104.5	126.5	no

the cumulative normal function for calculating the p-value in order to determine if H_0 can be rejected in favor of the alternate hypothesis H_1. However, if the cardinality of both sets is below or equal 20, precalculated tables listing exact U-values must be consulted to ensure a correct evaluations, which has been applicable in several hypotheses and of particular importance in hypotheses $H5_a$, $H5_b$ and $H9_b$, as relying on the p-value alone would have yielded different results in terms of significance.

Significant outcomes of H1, H2 and H9 confirm prior qualitative findings, indicating strong tendencies towards preferring AAA exergames over casual fitness games when examining students, gamers and active people. Moreover, controlling Quake 3 Arena with an ergometer seems to have been received far better than using it to operate Flappy Cycling (H10). However, it can not be confirmed that the people's fitness level nor their specific interest in bike riding are indicators for them to consider using fitness gaming devices at home. Nevertheless, clear tendencies can be discovered (H5, H7, H8, H11, H12, H13) and thus such assumptions should be of interest for further investigations.

5 Related Work

Gamification for health and fitness is an emerging trend that is frequently incorporated into smartphone apps or Internet portals. Games for fitness are closely related to those applications as they share the same goal: motivating people for a healthier lifestyle. This is accomplished by integrating exercise into games, a concept widely adopted in development for home gaming consoles but also scientific research. Most popular fitness games are part of series that are still ongoing to this day. It is noteworthy that all of those games specifically are tailored for exercising with various fitness devices or motion controllers and no attempts have been made to integrate exercising into games that were made without physical activity in mind, let alone into AAA games. Such experiments only seem to be undertaken by hobby craftsmen at the moment[14]. However, as *virtual reality* (VR) equipment like the Oculus Rift[15] goggles are on the verge of becoming publicly available, steps are made towards increasing player immersion by devising novel game input methods: for example, Virtuix[16] develop a virtual reality motion platform that lets players wander through the worlds of their favorite 3D games using their own feet. Similarly, VirZoom[17] uses an ergometer to achieve said effect, although currently only with custom made games. Using these devices, of course, does not necessarily implicate conducting a thorough workout, but definitely increases the amount of physical activity involved when playing games.

Many academic studies examine the effect of exergames on people's *energy expenditure* (EE), a measure that can be increased by physical activity and should not be exceeded by dietary energy intake, in order to prevent gaining weight. Jennifer Sween *et al.*, studying 27 papers on this subject, found a strong correlation between fitness games and EE [SWS+14]. Most of the research they investigated discovered that introducing such games resulted in test subjects meeting the *American College of Sports Medicine* (ACSM) guidelines for health and fitness [oSM+13]. The games used for the studies included interactive aerobic, cycling, motion capture, dance simulation as well as isometric resistance titles of all current major consoles – Microsoft XBox, Nintendo Wii and Sony Playstation. Although dance simulation games caused the most significant EE increases of about three times of a person's resting expenditure, not a single study reported any inconclusive or negative results. Furthermore, similar results were discovered in a literature review targeting the physical effect of exergames in healthy elderly [LSLL13]. Such outcomes, on one hand, emphasize the potential of fitness games, but on the other hand, do not account for their ability to change people's attitude towards exercising.

Scientific studies examining fitness games' effects on user behavior, depending on their research objectives, either use commercial exergames or create custom solutions. Conclusions are of mixed nature – partly positive [MVHV03, LML+06, PBBvDN09, BC10, BVSZ13], indicating an increase in physical activity, and partly inconclusive, reporting that no significant behavioral change can be identified [YSG08, BI10, BAB+12]. Moreover, in addition to a questionable incentive for long-term engagement, the games often simply lack fun [MVHV03, MLB13], which can be addressed using a variety of approaches: psychological or physiological considerations [MLB13], increasing the level of perceived accomplishment [MH06], introducing social and narrative components [KR09, LT13] etc.

Work most closely related to the projects presented in this thesis comprises user studies that investigate the effects of home fitness devices connected to exergames. Darren Warburton *et al.* examined 14 low-active young males partaking in a specifically devised exercise program over a 6 week period. They discovered a 30% higher attendance to ergometer training sessions when video games were involved as opposed to exercising the traditional way [WBH+07]. Ahn and colleagues turned a treadmill into an interactive running entertainment system, featuring a built-in computer, user-wearable sensor bracelets and an ultrasonic sensor for tracking a player's position [AKP+09, PYC+12]. They further developed "Swan Boat", a competitive team-based multiplayer racing game, in order to evaluate the entertainment system. A two-week study with 12 participants revealed an overall positive reception, beneficial social effects due to the necessity of team synchronization and increased engagement caused by high competition between teams. Yue Gao *et al.* also utilized a treadmill as well as a Kinect camera with a casual exergame to confirm that short exercise breaks throughout the day yield temporary benefits of cognitive nature, such as improved concentration [GM12]. Göbel and colleagues developed three exergames aimed at improving the long-term motivation of players: an ergometer controlled set of minigames incorporating vital signals from players as well as two other games tracking user movement via accelerometers and video recognition, respectively [GHW+10]. All captured sensor information directly influenced the gameplay, which generally had a positive impact on player motivation and experience, as they found in various focus group tests. Finally, Hoda *at al.* evaluated how user experience in ergometer-based exercise depends on the application context [HAES13]. They examined 20 participants in five different cycling settings: no addition, game, TV, game plus TV and game plus movie. Results showed that integrating workout into a game has been the most encouraging and motivational environment, while biking without any entertainment was mostly

[14] E.g. ManaEnergyPotion on Instructables, 2009: "Hooking Up A Treadmill to PC Game" (`http://tinyurl.com/zd2s36f`, Web. 29 Jun. 2016).

[15] `https://www.oculus.com/en-us/rift`, Web. 29 Jun. 2016

[16] `http://www.virtuix.com`, Web. 29 Jun. 2016

[17] `http://www.virzoom.com`, Web. 29 Jun. 2016

considered tedious.

6 Conclusions

This paper has introduced fitnessification as a way of improving upon current exergaming design concepts. Its major scientific contributions are prototype implementations, user experience studies and their evaluations.

6.1 Research Questions Answered

Q1 How do sportive/unsportive people feel about exergaming?
Although only very few participants actually play exergames, responses are overly positive and the majority of persons view exergames as healthy, entertaining, motivating and a novelty. Given that many would consider working out with either of the studies' prototypes, it can be presumed that there is still potential in fitness gaming.

Q2 Can exergaming be more fun?
Judging by the significant results (H1, H2, H9, H10) this seems to be the case. However, biases can not be ruled out, as control issues seemed to be disturbing factors in both studies.

Q3 Given the AAA game integration, would it be possible to motivate people to work out more?
It appears that less sportive regular gamers are not very much inclined to do so (H3), however, a tendency can be found when regarding both collected data sets separately (H5), which is definitely appropriate for justifying future research.

Q4 Which conditions must be satisfied for gamers to consider exergaming at home?
The overall positive results convey that the most important element is fun, as is reflected by participants' comments. Furthermore, additionally to being responsive in terms of controls, games ought to present an individually adopting challenge to their players. Lastly, volunteers' feedback suggests that they must be affordable, which as well underlines the importance of fun, because hardly anybody would want to buy expensive devices that are boring to operate.

6.2 Summary

A hybrid approach has been chosen for evaluating survey responses produced by 67 study participants. The initial qualitative data inspection suggests that the volunteers – predominantly young male students or technicians – mostly were committed to giving honest and constructive answers. Generally, the studies were very well received, although overall the Quake 3 Arena mod has been better accepted. Most issues reported during the experiments were regarded control-specific, which could have introduced a bias, hence, should appropriately be addressed in future experiments. Twofold quantitative analyses follow a confirmatory approach as well as investigating data correlations in an explorative manner. Since most of the questionnaire variables are ordinal, a Mann-Whitney-Wilcoxon test is applied for verifying research-relevant hypotheses. Findings include strong tendencies towards preferring AAA exergames over casual fitness games when examining students, gamers and active people. Moreover, controlling Quake 3 Arena with an ergometer seems to have been received far better than using it to operate Flappy Cycling. However, it can not be confirmed that the people's fitness level nor their specific interest in bike riding are indicators for them to consider using fitness gaming devices at home. Nevertheless, clear tendencies can be discovered and thus such assumptions should be of interest for further investigations.

6.3 Limitations

Although a population of 67 people is seemingly sufficient to conduct a thorough study, it certainly must be considered that they are equally split between two separate studies, which renders the samples less comparable and through partitioning both data sets often very few samples remain, occasionally not enough for a meaningful evaluation. Also, the typically short test durations are not necessarily beneficial for getting accurate ratings: as expressed in various comments, often more time is needed in order to adapt to the controls. Additionally, a change in user behavior due to being observed can not be ruled out but it is mitigated by not explicitly supervising the act of completing the evaluation questionnaire. Lastly, a presumed novelty effect could have been influential and should prospectively be addressed by introducing longer test periods.

6.4 Future Work

Several hypotheses suggest that there nevertheless seems to be some kind of relation between persons' exercising habits and their ratings for fitness games. It would be interesting to see if longer test periods could help improving the data collection process in order to discover more significant evidence in this regard. It further would be beneficial to set up several ergometer stations, maybe even letting volunteers compete against each other to increase the experienced social factor. Finally, long-term engagement should be examined since this would more accurately describe peoples' preferences and tendencies towards exergaming at home than the presented short-term approach.

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