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Maastricht University

Faculteit Wetenschappen
School voor Informatietechnologie
master in de informatica

Masterthesis

Serious gaming / gamification elements for apps promoting physical activity

Daan Van Dyck
Scriptie ingediend tot het behalen van de graad van master in de informatica, afstudeerrichting Human-Computer Interaction

PROMOTOR :
Prof. dr. Mieke HAESEN

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dr. Davy VANACKEN

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by

Daan Van Dyck

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Abstract

Serious games are a modern developing tool aimed at changing a player's behavior. They are often used in the context of health improvement. While serious games have been thoroughly studied for a considerable amount of time, we believe there is still much potential to be realized. One such subdomain which possibly harnesses much potential, is that of large-scale shared-world multiplayer experiences, as is empirically shown by commercial counterparts. We discuss, review and aggregate literature regarding motivational elements of this type of experience. In conclusion of this part of our literature review, we contribute a graph which shows how the discussed motivators relate to one another and how the graph can be used as tool to analyze or explore motivational design space. Subsequently, the most notable works regarding elements of persuasive design are discussed and aggregated. Both motivational and persuasive techniques are used in the realization of an experimental serious game aimed at exploring the possibilities regarding large-scale shared-world multiplayer experiences. Design choices, both technical and game design related, are discussed. Afterwards, a qualitative user experiment is discussed regarding the potential of aforementioned experiences. Results indicate large-scale shared-world multiplayer scenarios are well suited for the implementation of social motivators and elements of persuasive design due to their communitive nature.

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Contents

Chapter 1

Introduction

Serious games are a developing tool to condition target behavior to a player. The target behavior is often intended to increase an individual's personal health. Examples include applications aimed at reducing unhealthy eating or smoking habits. However, it should be noted serious games can span a wider area of purpose. They can also be used to sensibilize certain issues to their players. The many use cases for serious games, due to their flexibility, and the potential observed from both serious and commercial games makes them a promising research area. Games, both serious and commercial, have been studied by many scholars who tried to infer the essence of what makes them interesting or fun, in trying to reduce them to abstracted elements to be used in the realization of new serious games better able to motivate their players to perform some target behavior. Traditional research in this area is rather limited to games of which a single instance can be played by only a few people simultaneously, if not solely. Commercial games, however, offering a multiplayer experience involving hundreds to thousands of players, have had great success. Therefore we wonder, can a similar large-scale shared-world multiplayer concept also be applied in the context of serious games? Firstly, we ask ourselves: *which motivational game elements typically belonging to large-scale shared-world multiplayer scenarios lend themselves well to be implemented into serious games of similar concept and scale?* It is this question to which we formulated an answer in section 2.3 by performing a literature review of the most notable works in this context. However, the literature review is not limited

to motivational game elements. Chapter 2 begins with an overview of taxonomies and definitions of serious games to familiarize the reader with some of the theories and classification schemes of serious games. Throughout the chapter, we regularly refer to three serious games and contribute by classifying them as well as analyze their elements of persuasion and motivation. In review of the latter elements, we compiled an interaction graph which shows how motivators relate to one another and discuss how it is of use when analyzing or designing serious games. The graph forms the answer to our second research question: *how can motivational design space be explored?* Aside from motivators, motivational game elements, we discuss elements of persuasive design which often serve the same purpose: conditioning target behavior. We discuss some of the most notable works in this area and make a contribution by aggregating them.

After review of the discussed work, we set to design an experimental serious game in order to gather evidence to answer our third and last research question: *are large-scale shared-world multiplayer experiences better able to motivate players compared to traditional singleplayer serious games? And if so, does this outweigh the added complexity of designing, developing and testing this type of experience?* Doing so, we prototyped and implemented a serious game aimed at reducing sedentary behavior among players in an attempt to prevent the negative health conditions associated with said behavior. We discuss the target audience and their physical habits, the use case of the application and example implementations of many of the discussed motivators and elements of persuasive design. Subsequently, in chapter 4, we discuss the most notable technical challenges we encountered, during the realization of our serious game, and how they were solved. Furthermore, we discuss the technologies used as well as the architectural design of all applicational entities of our serious game.

Chapter 5 discusses a weeklong user experiment we conducted in order to obtain qualitative evidence regarding the third research question. However, we first briefly discuss the pilot test prior to our user experiment. Thereafter, we discuss the pretest questionnaires which were filled out by the participants. This discussion regarding

familiarity with games and sedentary habits elaborates on each participant's personal context needed to perform the qualitative analysis. Subsequently, some notable events which transpired during the user experiment will be discussed, including how we dealt with software bugs hindering the tracking of physical activity of some participants. Finally, we review the implemented motivators and elements of persuasive design, assessing the degree to which they failed or succeeded and why, while suggesting how future implementations can be improved. The review of these elements, both motivational and persuasive, is done on a feature-by-feature basis, analogously to how they were discussed in chapter 3. Some of the suggestions we present will be discussed in more detail in chapter 6.

Lastly, in this work we aim to help standardize the definition of the word "sedentary" as proposed by Barnes et al. By their definition, it refers to any waking behavior performed while in a sitting or reclining posture characterized by a low energy expenditure [1]. Therefore, the use of the word in this document will be defined as stated. This definition can be seen as a particularization of the definition of "physical activity" by Caspersen et al. [2].

Chapter 2

Literature review

In this chapter, we will discuss some of the most reputed works related to serious games. Starting with definitions and taxonomies, we show how they can extend and relate to each other, and how they can be used to subdivide, by applying them to uncategorized serious games. These definitions and taxonomies will later function as context when situating the serious game we developed, named "MOMG[1]". Subsequently, we discuss the most noted behavior model to be used as framework and reference to evidence the work of Yee on motivating game elements in the context of MMORPGs[2] [3], as well as to support our own claims extending Yee's work. Thereafter, these motivational game mechanics are comprehensively discussed: an extensive description of the mechanic in question is given, supplemented by commercial examples as well as academic research projects. Lastly, we propose a scheme which shows the relation between the previously discussed motivators. This scheme can be used as tool to explore motivational design space in terms of game mechanics when developing serious games or to analyze existing ones.

[1] Movement-Oriented Multiplayer Game

[2] Massively Mulitplayer Online Role-playing Game: a role-playing game where thousands of players inhabit a single virtual world.

2.1 Serious games: aggregating definitions and taxonomies

Many scholars have attempted to bring forth a generic definition of serious games. Arguing whether learning or behavior change should be the main objective of the game rather than the game being fun [4], whether serious games should be combined with traditional instruction methods [5] and reflection [6] in an educational context, whether individuals of the target audience should be directly involved in the design process [7], whether a serious game should be a simulation-oriented environment, where players learn by experimentation and discovery, or be a guided linear narrative [8], whether serious games should be played voluntary [9] or not. Due to this discussion many works include the author's own definition. However, the importance of a common terminology should not be underestimated. In this section, we will expand on popular definitions and taxonomies which try to bring structure to the field of serious games.

2.1.1 Taxonomy by Marsh

A first taxonomy we will discuss, was introduced by Marsh. Marsh proposes a one dimensional continuum divided into three groups [10]. Every game classified using this continuum is required to have some higher purpose, i.e. it must have a goal other than the entertainment of its players. We discuss three categories and provide example games, different from the ones mentioned by Marsh. The first category encompasses *all games showing traditional gaming characteristics*. These characteristics include common motivators, such as those discussed in section 2.3, typical graphical user interfaces and everyday input devices. A game called "Balance" by Fuchslocher et al. [11] falls into this category. Figure 2-1 shows an in-game screenshot. Clearly, this game has many traditional gaming characteristics: 2D platforms, three lives, objects to collect, objects to avoid, running and jumping, etc. making it analogous to popular classical Mario games [3]. The second grouping encompasses *all simulation-oriented*

[3]See `https://en.wikipedia.org/wiki/Super_Mario_Bros`

environments with fewer traditional gaming characteristics. An online browser game called "Logic Gate Puzzler" falls into the category. In this game, the player is asked to create a logic circuit which needs to satisfy a truth table. Figure 2-2 shows a screenshot of the game. When the player wants to evaluate his creation, he clicks the "Test" button to start the simulation. Many traditional gaming characteristics are absent from the game: a fantasy world, characters, storylines, etc. while some are still present: challenge, discovery, flashy graphical design and animations, etc. thus making the game fall into said grouping. The third and final category proposed by Marsh encompasses *all digital media created to elicit emotion and experience through encounters*. Games classified under this grouping have minimal to no traditional gaming characteristics. In addition, their interfaces and input device are often experimental. Fish'n'Steps serves as example of this category. In said game, designed by Lin et al. [12], happiness of virtual pets are a function of the player's physical activity, i.e. one's fish will be happy if and only if his owner performs sufficient physical activity. An overview of the fish's facial expressions is shown in figure 2-3. Furthermore, no other interaction with one's fish was possible; the player could only observe it. Lin et al. reported players mentioning feeling sad when their fish was unhappy; this serving as example of how the game elicited emotion. An overview of the discussed serious games is given in table 2.1. Lastly, Marsh promotes the idea of a consensus on the definition of serious games by the research community in order to avoid division and detachment.

2.1.2 Taxonomy by Sawyer et al.

When defining serious games, it is meaningful to involve the taxonomy proposed by Sawyer et al. [13], shown in figure 2-4. Their taxonomy spans two dimensions: one being the domain in which the serious game is applied, the other its goal. Sawyer et al. identified four domains. Firstly, the public health category encompasses serious games created and maintained by governments to protect the wellbeing of their citizens. Simulations showing how diseases spread serves as an example. Secondly, the research and academia category, encompassing all serious games developed to

Name	Goal	Gaming characteristics
Balance	Improve self-management of teenagers with diabetes mellitus type-I.	2D platforms, three lives, objects to collect, objects to avoid, running and jumping, challenge, discovery, player avatar, direct control over avatar
Logic Gate Puzzler	Teach how basic logic gates can be combined to form complex logic circuits.	challenge, discovery, flashy graphical design, animations, levels
Fish'n'Steps	Increase daily foot step count.	discovery, player avatar

Table 2.1: An overview of the discussed serious games.

Figure 2-1: A screenshot of a serious game called "Balance" [11].

analyze systems or people or explore concepts. For example, a serious game aimed at motivating students to attend classes. Thirdly, serious games can also be employed in a professional practice. A serious game about welding could be used to teach one the basics of the craft. Fourthly, all serious games which encompass personal aspects of an individual's life, such as staying active in order to avoid rehospitalization in the case of a person troubled by a cardiovascular disease.

We will now apply this taxonomy to the games discussed in section 2.1.1. The game Balance should be classified under disease management since the context wherein

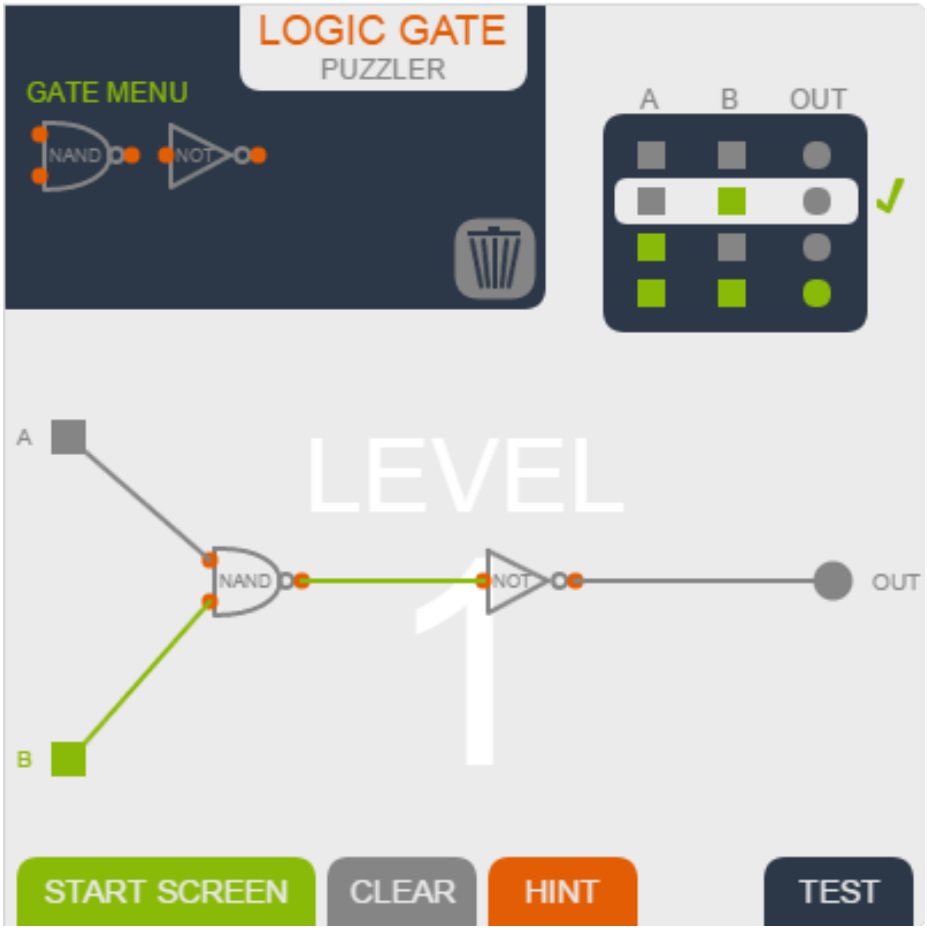


Figure 2-2: A screenshot of a serious game called "Logic Gate Puzzler".

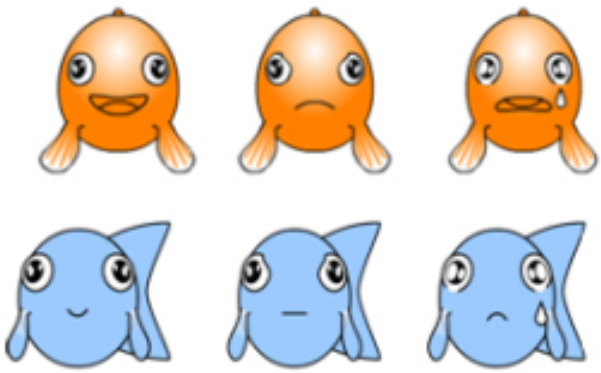


Figure 2-3: A screenshot of a serious game called "Fish'n'Steps" [12].

the game is played is personal and its goal, informing diabetes mellitus type-I patients about the interaction between food and the condition, is therapeutic. Logic Gate Puzzler would fall into the category of skills and training, as it is evidently educational

because of the purpose to teach about logic gates, while the goal can be applied in a professional context. Fish'n'Steps is an exergame since it aims to prevent physical conditions, hence the game must be categorized under preventive in one dimension and the context of application is personal.

McCallum's extension

McCallum proposed adding another dimension to games applied in a personal context [14]. This new discrete dimension classifies the type of health affected, distinguishing: physical health, cognitive health and, social and emotional health. The extension of the taxonomy is visualized in table 2.2. We note both the games Balance and Fish'n'Steps fall into the physical health category. Lastly, we argue it is useful to extend the Sawyer-McCallum aggregate taxonomy with the aforementioned categorization of Fuchslocher et al. This new aggregation would add another dimension to all areas of health and would allow serious games to be categorized by the degree to which they contain traditional gaming characteristics and the degree to which they are simulations.

Area of health activity	**Personal**			**Professional practice**
	Physical	**Cognitive**	**Social and Emotional**	
Preventative	"Exergaming" Balance Fish'n'Steps		Stress	Patient communication
Therapeutic	"Rehabitainment" Disease management	Disease management		Pain distraction Cyberpsychology Disease management
Assessment			Self-ranking	Measurement
Educational	First aid	Medical information		Skills and training
Informatics		Personal health records		Electronic medical records

Table 2.2: A part of the Sawyer-McCallum aggregate taxonomy. Only the part relevant to the discussion is visualized.

Table 1. The Games for Health Taxonomy developed by the Games for Health Project.*

Area of health activity	Personal	Professional practice	Research and academia	Public health
Preventative	"Exergaming" Stress	Patient communication	Data collection	Public-health messaging
Therapeutic	"Rehabitainment" Disease management	Pain distraction Cyberpsychology Disease management	Virtual humans	First responders
Assessment	Self-ranking	Measurement	Inducement	Interface and visualization
Educational	First aid Medical information	Skills and training	Recruitment	Management simulations
Informatics	Personal health records	Electronic medical records	Visualization	Epidemiology

Figure 2-4: A taxonomy for serious games proposed by Sawyer et al. [13].

2.1.3 Taxonomy by Ratan and Ritterfeld

Ratan and Ritterfeld proposed another taxonomy [15], obtained by performing factor analysis on several serious games databases. Their model consists out of four dimensions: primary educational content, primary learning principle, target age group, and platform. The first dimension, primary educational content, denotes the area of society the game was applied in and has six categories: academic education, social change, occupation, health, military and marketing. Fish'n'Steps and Balance would be classified under the health category, while Logic Gate Puzzler is assigned to academic education. The second dimension, primary learning principles, describes how a serious game will attempt to convey its message. It is subdivided into: practicing skills, knowledge gain through exploration, cognitive problem solving and social problem solving. Logic Gate Puzzler is clearly categorized in cognitive problem solving; Fish'n'Steps and Balance are classified in practicing skills. The third category, target age group, also consists out of four categories: preschool and below, elementary school, middle school and high school, and college, adult and senior. The fourth category, game platform, denotes the platform the game is played on, e.g. PC, smartphones, Xbox, etc. Note that games can span across multiple categories of the latter two dimensions. We remark that the Sawyer-McCallum aggregate taxonomy we constructed in the previous paragraph, can be integrated into the health category of the primary educational content dimension.

2.2 Fogg's behavior model

In the context of motivations, it is worth discussing Fogg's behavior model [16], one of the most reputed works in the field of behavioral science. The model, denoted by figure 2-5, consists out of two axes: ability and motivation. The former referencing to an individual's capability to perform certain behavior. In general, the more difficult it is to perform certain behavior, the less likely it is one will perform said behavior. This difficulty is a function of six attributes (time, money, physical effort, brain cycles, social deviance and non-routine). We state that the amount of physical effort and brain cycles required, are inherent to the behavior, while time, money, social deviance and non-routineness will variate per individual through time and space. However, an important consideration is that lowering the required amount of ability, will consequently also diminish the challenge involved in performing the target behavior. The desirableness of this implication varies in function of its context as empirical research [4, 17, 18, 19] has shown that challenge is one of the major reasons people play games. Therefore, it is imperative that ability and challenge, in a way tautological to each other, are well balanced with respect to the target audience in the context of serious games.

The latter axis, motivation, quantifies the individual's drive to perform certain behavior. Fogg differentiates three categories in which any motivation can be subdivided: pain/pleasure, hope/fear and social acceptance/deviance. Peer pressure serving as an exemplar of this last one. In games with a multiplayer component, especially MMORPGs, the drive to conform socially can be used to steer player behavior. For example, one could show the player's progress compared to that of others. In section 2.3 we will put motivational game mechanics in terms of Fogg's behavior model. Most of them can be deduced to the need for social conformation. Lastly, Fogg notes that there is a minimum amount of motivation required, regardless of the behavior.

Triggers are the last component of Fogg's behavior model. He distinguishes three types of trigger: facilitators, sparks and signals. The first two are events that re-

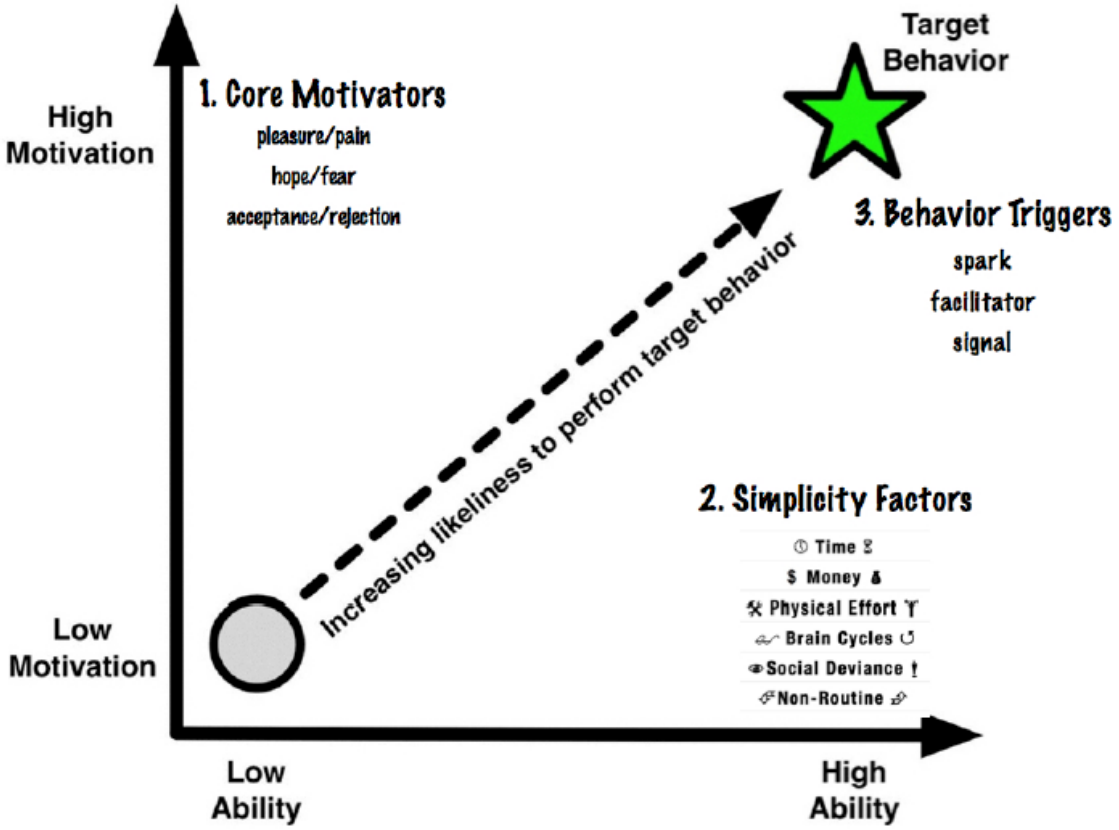


Figure 2-5: A graphical representation of Fogg's behavior model [16].

spectively raise an individual's ability and motivation above the required threshold. A facilitator accomplishes this by changing one of the six attributes associated with ability. Receiving a discount, i.e. lowering the amount of money required, on an expensive product could function as a facilitator. A spark motivates an individual by making clear how he could increase pleasure, hope or social acceptance or decrease pain, fear or social rejection. Watching an anti-smoking advert might make an individual fear the increased risk of cancer, and thereby, motivate him enough to stop smoking. Should an individual not be performing a given behavior while he has sufficient ability and motivation, then a simple reminder, or signal in Fogg's terms, could suffice in order to make him perform said behavior.

2.3 Motivating game mechanics

In this section, we will discuss motivating game mechanics commonly found in literature. In this field, one of the most reputed works is that of Nick Yee [3]. Using a survey he questioned 3000 MMORPG players and performed factor analysis to obtain an empirical model of player motivations in online games. This model consists out of three overarching categories which are further subdivided. An overview of his work is shown in figure 2-6. In support of his work we will aggregate popular examples and empirical research and categorize them using the grouping he suggested. Furthermore, other extensions, derived from related research or our own ideas, will be incorporated into the model.

Achievement	*Social*	*Immersion*
Advancement Progress, Power, Accumulation, Status	**Socializing** Casual Chat, Helping Others, Making Friends	**Discovery** Exploration, Lore, Finding Hidden Things
Mechanics Numbers, Optimization, Templating, Analysis	**Relationship** Personal, Self-Disclosure, Find and Give Support	**Role-Playing** Story Line, Character History, Roles, Fantasy
Competition Challenging Others, Provocation, Domination	**Teamwork** Collaboration, Groups, Group Achievements	**Customization** Appearances, Accessories, Style, Color Schemes
		Escapism Relax, Escape from Real Life, Avoid Real-Life Problems

Figure 2-6: Yee's motivational subcomponents grouped by category [3].

2.3.1 Achievement

Achievement, further subdivided in advancement, mechanics and competition, is commonly defined as completing a task successfully. In this context, said task requires a certain amount of skill from the player. This requirement is needed to clearly separate the achievement category from the other categories: social and immersion. For example socializing, a subcomponent of the social category, is a task which can be executed successfully but does not require skills specific to a certain game.

Advancement

Yee describes advancement as "the desire to gain power, progress rapidly, and accumulate in-game symbols of wealth or status". Advancement, also known as progression, is typically further subdivided in horizontal and vertical progression. Vertical progression is defined as any progression that makes the player more powerful. An exemplar of this type of progression is the levelling system found in virtually any MMORPG and RPG[4] in which each time the player levels up, his character is rewarded with an increase in hit point, attack points, etc. essentially making him more powerful, better suited for combat and in general more able to fulfil his role. Another exemplar would be the player acquiring more powerful items.

In games in which gaining power is not desired, typically to preserve fairness in highly competitive shooters (such as Overwatch[5], Team Fortress 2[6] and the Counter-Strike series[7]), horizontal progression can be used to provide the player with meaningful advancement. Often this type of progression is implemented by allowing the player to unlock cosmetic items, such as clothing and accessories. More rarely it is implemented by allowing the player to trade his characters abilities for one's of equal power (e.g. Diablo 3[8]). Lastly, advancement in storylines and narrative character development are also forms of progression, however these are not exclusive to games as they are also present in other popular entertainment media, virtually any movie, series or book.

It is worth noting that many popular games explicitly show the player's progression using the game's interface. Levelling systems are commonly presented as visually appealing progress bars. Some games, such as best-selling game Minecraft[9], go one step further and unnecessarily, from a technical perspective, embody experience as colorful particles making the act of progressing more clearly to the player. In popular

[4]Role-playing game: the singleplayer equivalent of an MMORPG.
[5]See `https://us.battle.net/shop/en/product`
[6]See `http://store.steampowered.com/app/440/Team_Fortress_2`
[7]See `https://en.wikipedia.org/wiki/Counter-Strike`
[8]See `https://eu.battle.net/shop/en-us/product/diablo-iii`
[9]See `https://en.wikipedia.org/wiki/Minecraft`

MMORPGs World of Warcraft[10] and Guild Wars 2[11], six out of eight types of quests (activate, compilation, defend, fetch, kill and profit quests), as enumerated by Smith [20], are either visualized by a progress bar or by wordings such as "x of y collected" or "x/y enemies killed". These examples all serve as empirical evidence supporting Yee's idea that progression, or advancement as he called it, can be used as a motivating game mechanic.

In academic research, Lin et al. used this mechanic to motivate players to perform physical activity [12]. In their game Fish'n'Steps players start with a tiny fish as avatar. The growth of their fish is a function of the amount of steps they take during a certain period. This means that fish of players who are more physically active will grow faster. The rate of growth of one's fish is thus the sought progress, which is used to motivate players to be more physically active. Additionally, in some versions of their user experiments, player's fish share a virtual fish bowl which makes the size of one's fish a symbol of status in Yee's terms. During post experiment interviews conducted by Lin et al. some players explicitly mentioned that seeing their fish grow, provided them motivation to perform more physical activity. Lin et al. also note that some players would not open the game in order to avoid confrontation with their fish when they thought it had not grown, as to not be confronted with their lack of progress we suggest.

One can also support the claim that progression is motivating by framing it in Fogg's behavior model [16], where the obtainment of status could be classified under the social acceptance motivator. Some in-game items might takes weeks or even months to acquire, as a result, players in possession of such an item show to others they invest a considerable amount of time into playing the game. In context of the game, others might look up to them for their dedication, which provides them social acceptance.

[10]See `https://eu.battle.net/shop/en-us/product/world-of-warcraft`
[11]See `https://www.guildwars2.com/en/the-game`

Mechanics

Player interest in game systems, and the rules out of which they consist, in order to optimize their own performance, is considered motivating by Yee. Trying to find the fastest route through an enemy stronghold is an example of this motivator. In simulation-oriented games, this motivator can be found in trying to find optimal placement of game objects, ratio of certain objects, etc. Popular social media game Farmville[12] serving as an exemplar. In Farmville, the player has to sell foods and beverages in order to gain in-game currency. Crafting these items requires ingredients: a bottle of champagne, for example, requires six white grapes and a bottle. In this example, if the player wants to optimize his production, he needs to harvest six grapes for every bottle he produces.

We propose two rationales that can be used to support the motivational attribute of this mechanic, both tie into Fogg's behavior model. The first rationale being that analyzing game rules and systems is an intellectual ability requiring socially revered skills, such as problem solving and abstracting. This claim is supported by the work of Paul [21]. On community forums of World of Warcraft, he noted comments which unambiguously show the social acceptance related to analyzing games, or theorycrafting as he calls it. One such comment reads "... me holding a deep respect for you number junkies". The second rational is that one theorycrafts because it will lower the required ability to play the game, i.e. playing the game becomes easier once an optimal strategy has been found.

Lastly, we remark that, interestingly, this motivator is ever present, for a game, by definition, consists out of rules and systems which can be analyzed by the player.

Competition

The fact that competition is considered motivating is not surprising, as it is present throughout western culture in sports, entertainment media and even education systems. Since the beginning of arcade games player performance has been quantified

[12]See `https://www.zynga.com/games/farmville`

to score, the highest of which were exposed for all to see. This phenomenon is more present than ever with new online technologies that can manage world leaderboards in real-time.

One can find many academic works in support of the claim that competition is motivating. Some of the most notable works will be discussed here. Olson surveyed 1254 children [22], of which at least 98% were between 14 and 16 years old, and concluded that 57% of boys strongly agreed (4/4) that they play games to compete with others. Among girls this was only 28%. Olson further points out that similar studies support his conclusion. One such study was executed by Tarrant et al. [23] who showed that adolescents prefer being good at a game rather than the game being fun. Another such study was performed by Funk et al. [24] who found that winning in a competition resulted in a sense of accomplishment which resulted in pride. We note that this phenomenon, satisfaction from winning in a competition, can be easily unified with Fogg's social acceptance motivator in his behavior model as the victory functions as proof of proficiencies in certain skills, which can be used to claim superiority socially. In the context of sport video games, Cianfrone and Zhang [25] report that Sherry et al. [19] found by means of focus groups that competition is second in their top reasons why people play video games. Cianfrone and Zhang also point out that competition is part of the Sport Video Game Motivation Scale developed by Kim and Ross [26]. A later study sought to improve this scale and confirmed its findings [27].

We note that empirical research often finds that challenge is also deemed motivating [4, 17, 18, 19, 28]. Challenge and competition are however strongly connected as the sought challenge in many gaming genres can only be created by interacting with other players, due to the fact that current AI technologies cannot yet compete with humans. Although the performance of AI agents has been improving the last decades, particularly in spatially discrete board games with perfect information (e.g. chess and checkers), they still have a long way to go. Modern spatially continuous popular strat-

egy games, such as StarCraft 2[13], League of Legends[14] and DOTA 2[15], require players to make real-time decisions, model their opponents, deal with only partial information, execute strategies involving multiple team members, plan ahead, etc. and thus requires human competitors to maximize challenge for now. Optimally, the difficulty would be adjusted per user. Göbel et al. implemented this idea in an exergame where they measured metrics such as the heart rate of the player, RPM, speed, etc. All data readings were passed to an adaptive engine which would adjust the game's difficulty appropriately [29]. Besides difficulty, other game parameters can be adjusted to maximize player satisfaction [30]. We note that in the context of MMORPGs other heuristics (e.g. amount of times player died in the last hour, time spent defeating an enemy, amount of players in the group) might be used to approximate optimal difficulty.

Lastly, by recontextualising the work of Tauer and Harackiewicz [31], we note that competitive game mechanics should be implemented with care as the game feedback's systems are crucial to enjoying the competition. For example, very negative feedback when the player loses, could reduce his motivation below the minimal amount needed to continue playing. They also note that even when said systems provide enough positive feedback, competition will most likely not appeal to every player as competitiveness is still a personal trait. In one of their later works they conclude that intergroup competition is found to be even more motivating than pure competition [32]. We will discuss this further in section 2.3.2.

2.3.2 Social

Humans, by nature, are social beings. Therefore, it is not surprising that Yee suggests three social motivating gameplay elements: socializing, relationships and teamwork. Olson's work supports this category by stating that 12% of boys and 8% of girls strongly agree (4/4) that they play games to feel less lonely [22].

[13]See `https://eu.battle.net/shop/en-us/product/starcraft-ii-wings-of-liberty`
[14]See `http://gameinfo.na.leagueoflegends.com/en/game-info/get-started/what-is-lol`
[15]See `http://store.steampowered.com/app/570/Dota_2/`

Socializing

Yee defines socializing in the context of MMORPGs as conversing with other players as well as helping them. Conversing is typically done through a textual chat system. The chat system is commonly set up in such a way that it allows the player to be part of multiple channels at the same time. In a way, the system and its interface still resemble an outdated variant of an IRC system. The scope of each channel can vary greatly as some channels are private between two players, while others can span virtual cities and contain hundreds to thousands of players. More recently, newer MMORPGs also provide voice chat. In most MMORPGs, players can help each other in various ways: they might be able to enchant each other with beneficial buffs[16], team up, borrow or give in-game currency or items of use, etc. In Fish'n'Steps, a typical chat system was included to converse with other players. In addition, Lin et al. noted players would also discuss the game in real-life with each other.

Yee's definition of socializing is rather brief. Therefore, we will tend to the work of Chen and Duh, who conducted a yearlong ethnography [33] in order to obtain a taxonomy of social interactions in MMORPGs. Five kinds of social interactions were categorized and will be briefly discussed as to later these types of interactions will be referenced in section 2.3.4. The first one being staging oneself: claiming an identity through appearance and character attributes. An exemplar of the former would be wearing the most powerful obtained gear rather than a more aesthetically pleasing set. Examples of the latter include the character's class, height, skin tone and race. The second interaction is termed "gazing", this is simply the act of the player spectating the virtual world round around him. Examples of this activity include: spectating a duel, watching people enter and leave cities, observing a role-play scene unfold. Proclaiming superiority over others is deemed a third social interaction. The most obvious way such an interaction can take place, is by comparing status symbols with one another, such as gear, in-game currency and ranking. Another example of showing superiority is by teaching others how to play, an activity of which Olson reports [22] that 9% of boys and 6% of girls strongly agree (4/4) is a reason to play

[16] A status effect influencing one or more rules of the game's systems.

a game. For a fourth type, Chen and Duh, state there are two types of encounters a player can experience: other-reinforcing and labelling encounters. During the former a player would, through some interaction, boost the self-conception of the interactee. Complementing one's accomplishments or skill serves as an example. The latter, labelling encounters, are defined as any encounter where one actor is defined in a new way. For example, deeming another player a cheater. The last category of social interactions, contains all social interactions which stem for the attitude the player has towards a collective. A player, for example, might not want to cooperate with elves, since he has had many negative experiences doing so in the past.

Relationship

Having the desire to create or maintain meaningful relationships with other players is a second social motivator according to Yee. These relationships most likely originate from either teamwork or other social interactions (see section 2.3.2). Many popular MMORPGs support this motivator by allowing players to manage friend lists. A friend list is typically implemented as a form which shows the player's online friends; often it also displays the friend's current location within the game world. The form most likely also enables the player to initiate a chat session with any of his online friends. Curiously, similar tools have been implemented in all major game distribution platforms, such as Steam, Battle.net, Uplay and Origin. Many MMORPGs incorporate more tools to allow players to plan and organize. Guilds, for example, can be seen as permanent groups which enable players to differentiate by rank within the guild. Other relationship management tools, such as calendars and shared-world instances allow player to organize and build relationships. Building relationships, through guilds or other means, makes the player part of a group, which in turn yields him social acceptance.

Alankus et al. developed multiple, both singleplayer and multiplayer, rehabilitation games aimed at retraining motor skills in stroke patients. They concluded the possibility of building relationships through games can be a powerful motivator, especially for patients living in isolation [34].

Teamwork

The act of multiple players working together coordinately in order to overcome an in-game obstacle, no one can tackle alone, is defined as teamwork or collaboration by Yee, and forms the last social motivator. In section 2.3.1, we noted the work of Tauer et al. [32] which suggests that competition and teamwork are synergistic towards each other when it comes to motivating an individual. However, intergroup competition is not always possible and/or desired. Lin et al. incorporated this mechanic in their Fish'n'Steps game and reported it received mixed reactions due to some individuals not liking the competitive aspect [12]. The previously discussed rehabilitation games designed by Alankus et al. allow stoke patients to cooperate with friends, family or therapists. In one game called "Dirt Race", the patient would wipe bugs of a car's windshield by making the appropriate gesture, while his partner would drive said car. Although Alankus et al. do not explicitly remark patients preferred multiplayer games to singleplayer games, it can be concluded to an acceptable degree of certainty from the remarks the patients gave.

The work of Beznosyk et al. aimed at exploring the design space of teamwork. In their work, they implemented six different cooperative game patterns and conducted a user experiment to test said patterns [35]. Beznosyk et al. reported players preferred three cooperative patterns; they will now be discussed in order from highest ranking to lowest ranking. Firstly, interaction with the same object was deemed the most fun by players. This pattern required players to simultaneously interact with a game object, concretely, the object was too heavy and required two players to be moved. Another example of an implementation of this pattern would be a scenario where multiple buttons would need to be pressed simultaneously and each player could only be pressing one button. The second pattern is complementary roles, which means players do not have an equal skill set, and therefore, are dependent on one another to complete an objective. Dirt Race implements this pattern. Thirdly, players reported enjoying using an ability on another player. For example, giving a speed boost to a teammate.

In many MMORPGs a significant proportion of the game's content is designed for groups of players. Virtual strongholds, so-called dungeons or raids, are locations in the game world no player can tread alone, forcing players to organize and unite themselves. Often these challenges are tackled by guilds. Guilds are player-created social hierarchies, like conventional groups but persistent over longer periods of time and contain more members. Their function is to aggregate players with shared objectives, such as raiding said virtual strongholds or engaging in role-play.

2.3.3 Immersion

Immersion in the context of this work is typically defined as the feeling of being part of a fictional world. Traditional sources of entertainment, such as books and movies, commonly share this attribute. Although these traditional sources of entertainment have been studied intensely, resulting in a great understanding of tools and techniques to establish highly immersive universes, we note that due to the interactive nature of games, other paradigms might be needed to construct an immersive game, as the presence of interactivity changes the user's experience. A study conducted by Ritterfeld et al. shows that interactivity can have a positive effect in learner engagement [36]. They also note that interactivity elicits interest in an activity. These findings suggest that immersing players in a fictional world using games, should be easier than in traditional sources of entertainment. Yee broke the notion of immersion down into four subcomponents: discovery, role-playing, customization and escapism.

Discovery

Discovery, as defined by Yee, is the act of finding out about things. This motivator can be implemented in several ways. The first, and most obvious, implementation would be spatial exploration. Commercial games, The Elder Scrolls: Skyrim[17] and Fallout 4[18], both very successful and highly praised games, capitalize on this motivator by creating virtual fantasy worlds spanning an estimated 14 km^2 and 9 km^2 respectively.

[17]See `https://elderscrolls.bethesda.net/en/skyrim`
[18]See `https://www.fallout4.com`

Apart from mountains and vegetation, these worlds are filled with mysteries, persons, animals, quests and other game mechanical systems, allowing for far more than just spatial exploration. Any game composed out of levels, such as Balance, allows for simple discovery. However, creation of enormous virtual worlds is a costly and time intensive operation, therefore they are only handcrafted by large game developing companies who possess the vast amount of resources required in their creation: large budgets, talented artists and programmers. Due to these requirements, academics and small game development companies, can only attempt to recreate this kind of adventurous experiences by relying on procedural content generation algorithms. The exemplar in this context is best-selling game Minecraft, which implements an infinite procedurally generated world, essentially allowing for endless discovery. Furthermore, all 2^{64} possible Minecraft worlds are different from one another, allowing for a new experience when replaying the game. While the advantages of these procedurally generating algorithms are clear, designing them is a difficult task, since they often use complex models with many parameters, which need to be thoroughly tuned as only a subset of their values will produce the desired result. In addition, they are often, such as in the case of Minecraft, required to be able to run in real-time while not detracting the playability of the game. If they cannot run in real-time under these restrictions, generating another part of the world would require the player to suspend his playing, interrupting the experience and voiding any built-up immersion. Besides the game world, other game systems can also be discovered. For example, the crafting system in Minecraft does not show the player what items can be combined. Another example would be the growth of one's fish in Fish'n'Steps, allowing a player to discover the other sprites used to resemble his fish.

Role-playing

Role-playing is the act of taking on a fictive role or persona, a type of play MMORPGs lend themselves to due to their vast universes. Character storylines, history and other elements of fantasy are part of this motivator according to Yee. Character storylines

are stories told by players and NPCs[19] throughout the virtual world. The stories told by the latter could involve player interaction by being told through one or more quests. Dickey lists six different types of quests: bounty quests, Fed Ex quests, collection quests, escort quests, goodwill quests and messenger quests [37]. This enumeration is indeed analogue to the one listed in section 2.3.1. Each type of quest serves as example how the player can be integrated into an NPC's narrative. For example, A NPC might explain the player he has to collect deer meat for him and his family in order for them not to starve to death. Baranowski et al. suggest these episodic stories or quests, are an effective tool to capture the player's attention, and might motivate him due to their melodramatic nature [38]. They further argue narrative can be used to steer behavior change, since behavioral changes in fictional characters serve as a role model for the player, possibly triggering a related change in his behavior. In one of their later works, they coin the idea of making narrative progression conditional to player behavior change, suggesting the intrigue of a story might be able to push the player towards the desired behavior [39].

Van der Meijden et al. indirectly studied the motivational effects of real-life role-playing in a typical educational context [40]. In their work, sixth graders were assigned to one of two conditions. Students assigned to the construction condition would take on the role of a teacher developing a memory game for his students to play. Students in the play condition played an already existing game. Their results significantly favored the role-playing condition.

Lastly, we note game developers should carefully consider the degree to which role-playing will be implemented as players' desires to role-play varies greatly. Developers of many popular MMORPGs recognized this diversity and decided to create dedicated role-playing servers. On these RP-servers, strict naming and behavioral conventions apply and are to be respected as to not disturb the role-playing or immersion of other players. Curiously, the communities playing on this type of servers decide even more granularly the degree to which one is expected to role-play on their server, whereas, to the developer, the rules that apply are no different. This behavior has

[19]Non-player character: a character not controlled by any player.

been observed in World of Warcraft where some servers' communities require third-party add-ons to be present in the game client to further enhance the game's role-playing capabilities. This observation shows the diversity in players' willingness to role-play and should caution serious game developers, making them reevaluate their target audience's desire to role-play as to not discourage their potential playerbase.

Customization

Allowing players to personalize their virtual avatars is considered motivating by Yee. While Yee only discusses customization with regard to superficial elements, we propose to subdivide customization into two categories: those customizations that serve a cosmetic function (**Cosmetic**), such as skin color, race and gender; those that act as variable in the underlying rule systems of the game (**Functional**), such as armor, accessories, weapons and abilities. The former being Yee's definition of customization. The proposed categorization is logical and useful for a game designer. Since cosmetic items are solely made out of textures and models and thus can be created easily without the developer having to worry about them impacting gameplay in a negative way. Whereas functional items, might require additional programming secondary to textures and models and might impact game systems, potentially creating game balance issues. Note that elements of customization can be both cosmetic and functional at the same.

The amount and degree to which cosmetic elements are present, varies greatly between MMORPGs. There are two common approaches in character customization. One approach allows the user to choose among presets of textures and/or models. The main downside to this approach is that a high amount of customization requires much development resources, as each preset is designed by the developer, consequently also giving said developer a high degree of control as to what characters can be created, and thereby avoiding players creating immersion breaking caricatures but also severely limiting their options. Popular MMORPG World of Warcraft uses this approach, see figure 2-7. The other approach consists out of having the player manipulate his character by using a slider. The thickness of a cheek or the character's height,

for example, could be controlled this way. Using this approach, the developer can only set a minimum and maximum per attribute, allowing for more diversity at the cost of technical complexity, as the models and textures might have to be created procedurally. Many MMORPGs, such as Guild Wars, and RPGs, such as The Elder Scrolls V: Skyrim, use a combination of both approaches, see figure 2-8. A survey conducted by Turkay and Adinolf denotes character customization as one of the main motivators to play. Interestingly, this motivator appeals significantly more to female players [41].

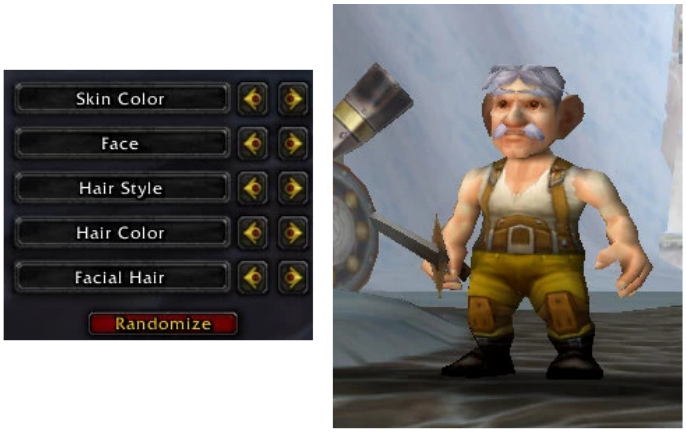


Figure 2-7: A control panel (left) used to cycle through presets to design a character (right) in World of Warcraft.

Virtually any MMORPG, RPGs and many others games allow players to customize their set of abilities. This is often done through skill trees or perks. Skills tree can be thought of as graphs where each node represents some bonus and an edge from node A to node B implies skills A requires skill B, see figure 2-9 for an example. The absence of any functional customization system implies players cannot deviate from the intended play style. In order to have interplayer variations, it is important one cannot acquire all perks or skills in a skill tree. A survey conducted by Turkay and Adinolf shows 71% of players rate this type of customization important to very important [41].

Why do players want to customize their characters? In general, players like a fictional character more if they consider themselves similar to said character [11]. Mertsalmi and others argue players like to experiment with different identities [42].

Figure 2-8: A control panel (right) allows the player to design a character (left) using sliders, for attributes such as iris size, and presets for eye color in Guild Wars 2.

Figure 2-9: A skill tree of a druid in World of Warcraft.

Firstly, by creating their avatar in their image, they try to experience the virtual worlds as if they were there themselves. Furthermore, they are curious how these experiences will reshape their identity. The virtual world also serves as safe space to

experiment with variations of their identity or with made-up identities. For example, a player could be very rude or very kind in the virtual world and see how these behaviors influence those of others. More supporting work for this theory [43, 44] was identified by Olson [22].

Escapism

Escapism is forgetting day-to-day situations and becoming fully immersed in the game world. Some perform this behavior to relax, while others might engage in it to avoid real-life problems. The latter being self-destructive behavior. Several studies have found that this motivator is a good predictor of gaming addictions [45, 46, 47]. More supporting evidence of this motivator includes Olson's findings: 13% of girls and 23% of boys strongly agree (4/4) with the claim they play games in order to relax. Furthermore, 18% of girls and boys strongly agree that games helps them to forget their problems.

Lastly, we will unify this motivator with the motivational axis of Fogg's behavior model, discussed in section 2.2. Fogg states that all motivations can be categorized in three motivational dichotomies: pain/pleasure, hope/fear and social acceptance/deviance. It is clear that each of these categories can contain negative experiences an individual might want to avoid. Concerning the pain/pleasure category: one might play a game in order to avoid feeling physical pain, as dedicating cognitive resources elsewhere eases the experience of pain. This concept was deemed successful by Morris et al. [48] who applied it in the context of burn injury patients performing physiotherapy. Concerning the hope/fear and social acceptance/deviance categories respectively: one might play a game in order to escape from his fear of losing his job or because he gets socially rejected in real-life.

All this evidence shows the potency of this motivator. However, from a game designer's perspective, we think there is no clear approach on how to design for escapism. In contrast to other motivators, competition for example, it is generally easy to introduce mechanics allowing for players to be competitive. When it comes to escapism, we think a coherent fantasy setting might be the only way to evoke this

motivator.

2.3.4 Interactions between motivators

In section 2.3, we elaborated on motivating game elements as enumerated by Yee in isolation. This was rather awkward since most components have either synergistic tendencies with each other or some other form of interaction. In this section, we will build upon Yee's conclusion by remarking any relations between two components. Figure 2-10 shows a graphlike structure, to be used for reference. Note that the socializing component has been upgraded by including the already discussed work of Chen and Duh [33] and the customization motivator has been expanded by our suggestion made in section 2.3.3. The graph was obtained by comparing each two elements and asking three questions. Firstly, *does one motivator require the other motivator to be present?* If so, then a *requires* relation is present. Secondly, *does implementing one motivator allow the other motivator to be implemented in new ways by the game designer?* If so, then a *allows for* relation was found. Let us consider the following two examples: advancement *allows for* customization to be implemented in a new way by having the player unlock either cosmetic or functional items through a progression system and competition *allows for* advancement by making progression in some game system conditional to a competitive aspect, such as the amount of players defeated by the player. Lastly, *does implementing one motivator enable the other motivator to be experienced differently, possibly strengthen it, without additional interference of the game designer?* If so, then we say one motivator *enables* the other. Role-playing, for example, enables the player to experience escapism, without requiring any additional implementation of the game developer. Many social interactions are *enabled* since their occurrence is conditional to player behavior and would therefore be difficult to *allow for*, to intentionally design for. One might argue that some relations are missing by giving an example of how two motivators are significant to one another, for example by stating that mechanics enable escapism, since analyzing game systems might make one momentarily forget about his daily life, hence we do not consider the presented graph to be final. However, we think relations should only be added

after careful consideration they are sufficiently significant, since any motivator can be thought of as an enabler of escapism, regarding the example. In the remainder of this section, we will discuss some notable components and relations as well as discuss how the graph can be used as tool. The graph answers the research question: *how can motivational design space be explored?*

The graph can be used as tool to infer how the motivational effect of a particular motivator can be maximized. For example, suppose a researcher wants to encourage some behavior among adolescents. A survey is used to assess the interest of the target demographic and shows competition is considered highly motivating. Subsequently, the researcher might use the graph to infer how competition is related to other motivators, to implement them, by looking at the incoming edges of the graph in the competition node. Alternatively, the graph can also be used to prevent inclusion of certain undesired motivators when one is designing a serious game. Suppose the target demographic dislikes competition, then the graph can be used in the same way, by analyzing incoming edges to identify affecting motivators. In this example, one should not implement game systems which allow for comparison between to players nor implement publicly visible progression systems. Lastly, it can be used as tool to analyze realized games and obtain further insight into how the game is able to motivate its playerbase.

Cosmetic customization is in its essence differentiation, and therefore, ties into many social motivators, predominantly into staging oneself and comparing. It also ties into competition as the size of one's collection of customizable items, and the rarity thereof, can be used in a competitive way. Functional customization has both *enables* and *allows for* relations since this type of customization is essentially changing parameters and/or rules in some game system, and therefore, its implications are often difficult to foresee as game systems can harness great complexity. Teamwork, competition and mechanics are typically part of the most complicated game systems of a given game. Therefore, functional customization will have the most influence in this area. Lastly, both cosmetic and functional customization tie into role-playing because both can be used to make one's avatar adopt personalities, allowing the player

to differentiate himself from others.

We think role-playing requires either functional or cosmetic customization, preferably the latter, for the player to be able to adopt the desired role to a satisfactory degree, although one could argue that this requirement is strictly not necessary. Notice how all edges leaving and entering role-playing are *enable* edges. This is due to the fact role-playing is predominantly a social interaction, and like many of its related motivators, this make it difficult to design for.

Advancement harnesses much potential to be related to other motivators, including some social ones. It gives game designers the option to lock away game content from players until certain criteria are met.

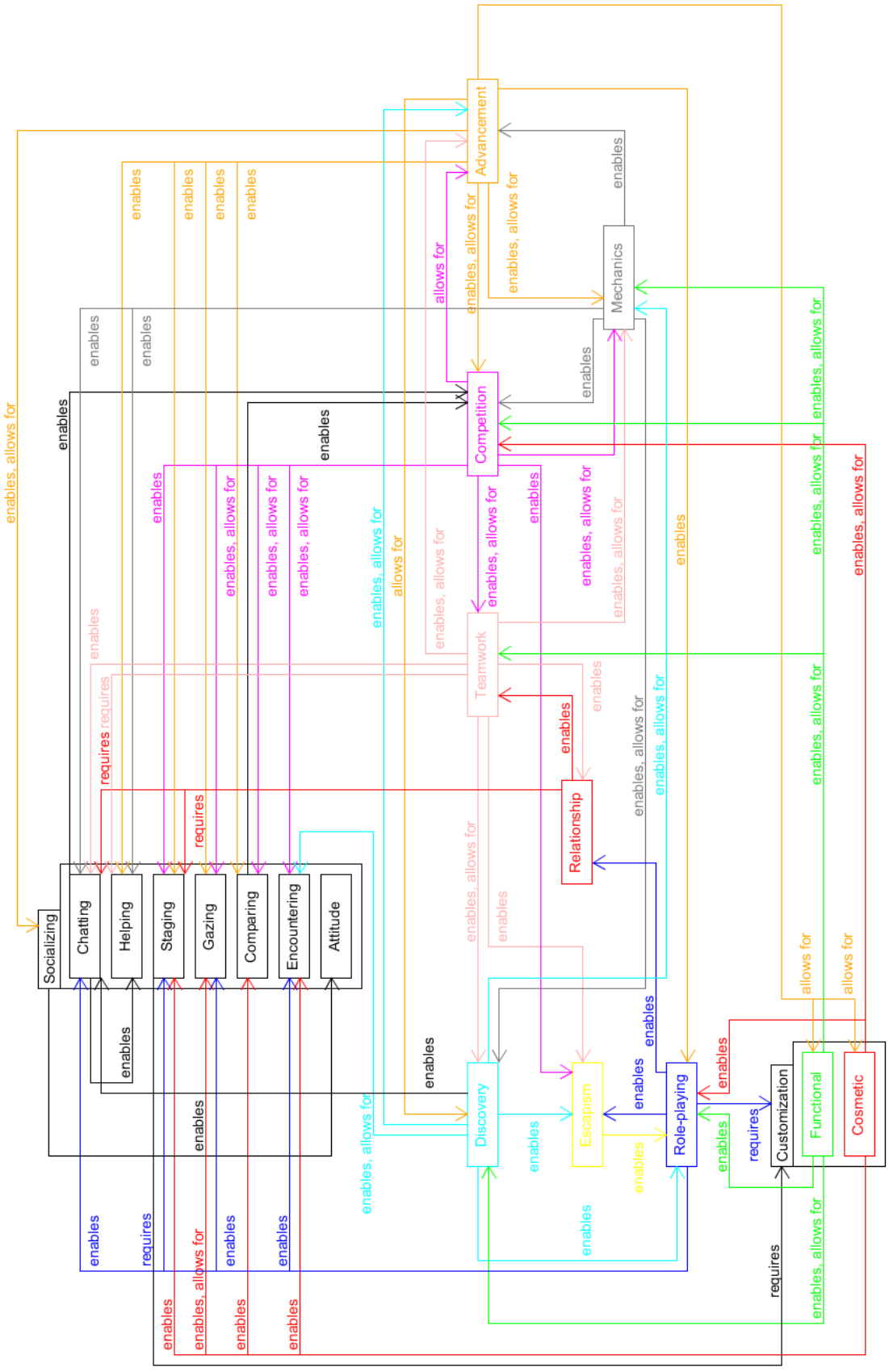


Figure 2-10: An overview of interactions between motivators.

2.4 Persuasive design

Aside from in-game motivational mechanics, discussed in section 2.3, which can be used to gamify a mundane activity, one can also incorporate persuasive techniques to steer a person's behavior. This area has been studied intensively in recent years and it is in this section the most reputed works of the field will be discussed. We will mainly be guided by Fogg's book, titled "Persuasive Technology: Using Computers to Change What We Think And Do" [49], and connect relevant research to support or extend his work. We will discuss all parts of Fogg's functional triad and their subcomponents. Lastly, the aim of this section is to familiarize ourselves with the persuasive design paradigm, as we intend to use it while constructing our own serious game, while identifying concrete techniques to use. Credibility is another major aspect of persuasive design. However, it will not be discussed as we have no intend to use it.

One of the earliest works on persuasive technology, is that of Fogg [50]. In this work, he is among the first to introduce a definition for persuasive technology. Paraphrased, his definition goes: persuasive technology is any interactive systems designed to change the interactee's behavior, attitude or feeling towards a particular issue. We note the inclusion of the word "interactive", needed to differentiate persuasive technology from traditional media such as television and magazines, which often also include persuasive messages. We also note the fact that persuasive systems need to be designed as such; they cannot be accidentally persuasive.

2.4.1 Fogg's functional triad

In his earlier work [50], Fogg coins the idea of there being three non-exclusive categories used to classify persuasive technology, the so-called "functional triad". These categories are: computers as persuasive tools, as persuasive media and as social actors. In his later work, he refines this idea [49]. These three categories will be discussed in the upcoming subsections. By studying them, and situating new example applications, including some serious games, we aim to get a better understanding of the persuasive strategies each category allows for, with the aim of incorporating them

into our own serious game.

Persuasive tools

Computers' abilities to store and process vast amounts of data make them excellent tools in multiple scenarios. Using them as tools can have persuasive implications, Fogg recognized seven. Each persuasive influence will be discussed below and examples of our own will be given.

Reduction Reduction of task complexity, simplification in other words, is about minimizing the required amount of effort one needs to perform to complete said task. For example, recruiters contacting soon-to-be graduates and offering to help them find a job. In this example, the recruiter performs some tasks the graduate would normally have to do himself, e.g. search companies, contact them, await a response, etc. In the context of this work, reducing the burden of activity tracking is also a form of reduction. The alternative being a person writing down all the activities he performed. Logic Gate Puzzler can also be seen as a reduction, since physical experimentation with logic gates, thus without simulation, is a difficult task, as obtaining the required components, connecting them and powering them, would require much effort. We note the principle of reduction can be applied by lowering any of the six variables related to ability in Fogg's behavior model, discussed in section 2.2.

Tunneling Tunneling is the act of captivating an audience, user or player, and make them experience predetermined content, trying to persuade them while doing so. A health practitioner who's trying to persuade a patient to enroll in a telerehabilitation program could apply this techniques as follows. He could first tell the patient about the program, mentioning what it entails and the possible benefits he might experience, should he take part. Then, he could show the telemonitoring application, and finally, he would ask the patient if he would like to participate. We note that many sales persons also employ this method. For example, a car salesman would first talk about a particular car on display, afterwards, he would ask the potential client if he would

like to enter the vehicle. We argue difficulty systems in games can also be seen as a tunnel, where each part of the tunnel could be a level with increased difficulty, compared to the previous level. Guiding the player through this tunnel, instead of making him face the tougher challenges immediately, allows for him to learn while traversing the tunnel, and consequently reduce the experienced challenge involved, i.e. invoking the reduction strategy this way. Logic Gate Puzzler's level system fits this description. At first, it requires the player to make simple logic gates, such as AND-, OR- and NOT-gates. At later stages in the game, the player is expected to build more complex logic gates. Balance also applied this method in its level system.

Tailoring Changing the presentation of a message, be it wording, structure, etc. as to personalize it, can have a persuasive effect. Fogg differentiates between two types of tailoring. Firstly, a message's presentation can be a function of the addressee. It could incorporate attributes such as age, language skill, education, income, etc. An exergame, aimed at increasing the amount of physical activity performed by the player, might show an already sportive player a message like "Taking 500 steps more than your average today should be no problem for someone as fit as you.", while it may show a message like "Taking 500 steps more than your average today should be no problem as you have had some days to rest.", to a player who has been less active the past few days. While the former is an example of the first, and already discussed, type of tailoring, the latter serves as an example for the second type: tailoring a message to someone's context. This type is more difficult to accomplish, since it requires the application to continuously gather and process contextual user data. Furthermore, it requires more development resources to be spent, as potential contextual parameters need to be identified and be incorporate into a persuasive message creation system. We note that, in general, serious games are often played by users with varying health conditions, and therefore, must be easily adaptable to a patient's needs, thus also require tailoring. For example, difficulty of a serious game can also be tailored, as advocated by Alankus et al., to ensure all players can be challenged [34].

Balance incorporates this technique: Fuchslocher et al. made two versions of their

serious game. In one version, players had to navigate a platformer while keeping their blood sugar at an appropriate level by eating or avoiding certain foods. In the other version, temperature was used as an analogy for managing diabetes mellitus type-I. The former was called the explicit version, the latter the implicit one. Fuchslocher et al. reported that players with diabetes mellitus type-I liked the explicit version more, since players liked the fact the game was personalized, i.e. they preferred the tailored message.

Suggestion The mere fact of perceiving information can invoke a trigger, a signal, as discussed in section 2.2. However, the trigger must be presented at just the right moment to maximize its effectiveness. While smart devices have made analyzing the user's context significantly easier, for they have access to his location, his schedule, the fact whether he is moving, etc., it is still challenging to find the most opportune moment. Additionally, the attitude towards applications promoting messages throughout the day, will vary greatly between users. Some might find them invasive and annoying, while others would not mind. Virtually all social media use suggestion thoroughly. Facebook and LinkedIn, for example, will notify a user when someone has accepted a friend request and invite them to logon to check out their profile.

Self-monitoring Computers as tools can also be used by an individual to monitor himself. Many serious games, aimed to improve one physique, measure the user's activity through sensors. Some use dedicated devices, while others try gathering the required data through one's smart device. The advantage of the former being the standardized hardware, easing development of applications, as the amount of outliers and other data-related issues will be minimal. Furthermore, dedicated hardware is always equipped with the desired types of sensors. Dedicated hardware, however, is expensive to develop. The alternative, using one's smart device, can therefore be advantageous, depending on the context. Their advantage mainly consisting out of a combination of their ubiquity, price and data processing/storing capabilities. However, smart devices, due to their heterogeneous hardware, might not be equipped

with all required sensors.

Interestingly, Fogg notes the persuasive aspect of self-monitoring is due to people's desire to understand themselves. Fish'n'Steps incorporates the self-monitoring technique as players would monitor their physical activity indirectly by the growth of their fish.

Surveillance It is generally known people behave differently when they know they are being watched by others. Fogg notes this fact can be used to influence behavior by setting up surveillance technology. For example, in the context of rehabilitation, such a technology could report a patient's physical activity to a health practitioner. When a patient knows he is observed this way, he is more likely to follow the practitioner's prescription in terms of physical activity. In one trail of Fish'n'Steps, players are not only observed by an external entity, the researchers, but additionally by other players as well. If a player did not perform enough physical activity, the water in the fish tank would become unclean and plants would die. Should this happen, players with small fish are to blame since physical activity did also increase the size of one's fish. Observation in this context, drives individuals to behave like other individuals within the group. Alankus et al. reported stroke patients remarking that they would be more motivated to play rehabilitation games when they would know they would be telemonitored by a therapist [34]. Lastly, Fogg notes the importance of people being aware of the fact they are being watched, as opposed to merely being filmed. We clarify with the following example. Suppose an office of several workers is being filmed by a surveillance camera. Now, suppose two scenarios: the camera might film them for years without ever being mentioned in a remark by the employer. Would people still feel observed? In the second scenario, suppose the employer would say to an employee: "I noted you stayed late last Friday, is the workload bearable?" In this case, when the employee is assured the camera images are watched by the employer, the persuasive aspect can be significantly more effective, as opposed to the former scenario.

Conditioning Operant conditioning is a persuasive technique which uses rewards or praise to stimulate target behavior. These rewards can take on many forms, ranging for virtual goods, such as in-game currency, items and other status symbols, to audio and visual effects, like virtual fireworks. Many types of rewards of the former type tie into the motivators identified by Yee, discussed in section 2.3. One example is the reduction of movement speed of the player's avatar in Balance, when certain foods are eaten.

Interestingly, the effect of this technique is increased by proper pacing of the rewards [51]. The player is rewarded often in the beginning of the conditioning and the frequency of rewards decreases in time played. Many MMORPGs and RPGs leveling systems are designed this way, see figure 2-11. The early levels of one's character require far less experience points than the later levels.

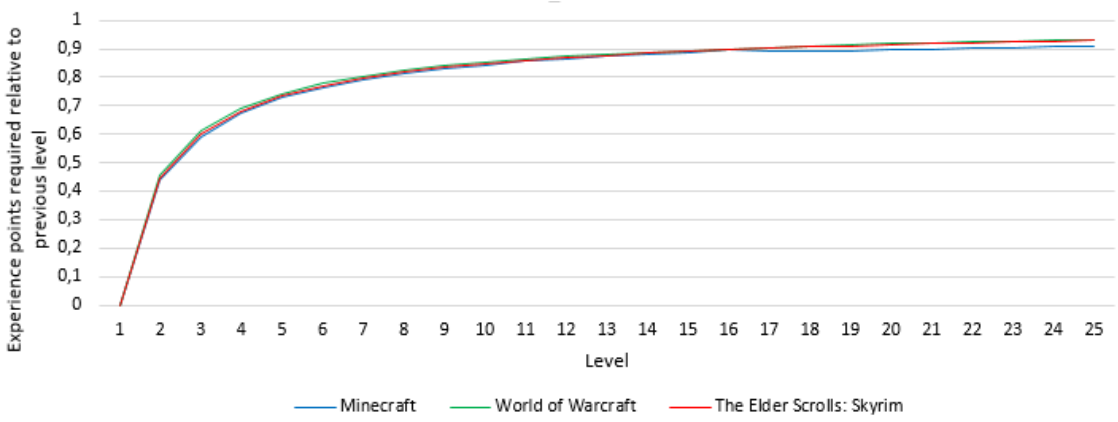


Figure 2-11: Additional experience points required relative to the previous level.

Persuasive media

Fogg recognized three categories to subdivide persuasive technology employed as medium: cause-and-effect simulations, simulated environments and object simulations. The latter will only be discussed briefly in this introduction as its only relevance to this work is the completeness of the taxonomy. The former two will be discussed in the follow sections.

Object simulations aim to persuade the user through interaction with a simulated

but physical object. For example, a therapist could use a mechanical spider to treat arachnophobia, by creating scenarios where the patient would interact with the robot. The amount of resemblance of the robot to a real spider, in physical appearance and behavior, could vary as the therapy progresses.

Cause-and-effect simulations Cause-and-effect simulations often aim to point out how a particular set of variables relate to each other over a long period of time. For example, think of an application that would ask the user how many disposable plastic bags he receives on average during one week. The user answers the prompt, after which the application plots a pyramid made out of thrown away plastic bags, next to an enormous and famous building, assuming every other citizen consumes the same amount of disposable plastic bags. The cause-and-effect simulation would in this way make clear how much plastic is wasted each week, hoping the user will persuaded to halt or reduce his use of disposable plastic bags, in favor of non-disposable ones. The serious game Balance falls into this category. The relation between the intake of certain foods and their effects on the avatar's blood sugar level is shown. The growth of a player's avatar in Fish'n'Steps is also a cause-and-effect relation.

Simulated environments Simulated environments are the last type of persuasive media identified by Fogg. In such an environment, an individual is able to safely experiment with behavior, without having to live with possible negative consequences caused by performing said behavior, much like cause-and-effect simulations. However, by this definition, we asked ourselves the question: are Balance and Logic Gate Puzzler not simulated environments as well? And yes, to a limited extend they are, as are virtually all video games, however, we chose to not classify them as such, since we think this definition needs to be further narrowed down. Persuasion using simulated environments should happen through more complex interactions with said environment than in the games mentioned. A virtual reality game where a player has to escape a burning building as quickly and safely as possible, for example, would classify as a simulated environment. To maximize persuasion, the game's environment

would have to match a real-world scenario: smoke would limit the player's vision and a lack of oxygen could slow movement and cause dizziness. However, this game could also be classified as a cause-and-effect simulation, since it allows the player to experience the effects of his actions and causes of his virtual deaths. Therefore, we conclude the line between these categories is too shallow to provide a meaningful distinction.

Social actors

Fogg states human-computer interaction can be persuasively influenced by the physical and psychological attributes of the technology, the language it uses and by employing social conventions and roles. These five aspects will be discussed in this section.

Physical attributes A system can be made to look human-like by giving it eyes, a mouth, a complete face, etc. Fogg states these physical attributes will increase the persuasiveness of the system. They accomplish this by establishing a social presence through their physicality, which in turn triggers a social response as human are conditioned this way. Furthermore, in general, the more a player can physically relate to his avatar, the more he will identify with it, and will consequently be more easily persuaded. Fogg emphasizes the importance of the visual appeal of an interface. A realistically three-dimensionally rendered face will be more effective than a simpler two-dimensional adaptation of that same face.

This technique was used by Lin et al. to give their fish in Fish'n'Steps an anthropomorphic look. We compared their fish, seen in figure 2-3, to a real goldfish and recognized four anthropomorphic attributes. Firstly, the heads of fish in Fish'n'Steps are rounded, similar those of humans. Secondly, the positioning of their eyes, on the front sides of their faces and relatively close to each other, as opposed to most real fish, which have their eyes to the side of their heads, is atypical and similar to humans. Lastly, their mouths take on human-like shapes, while their fins resemble arms.

Balance also used this method, as seen in figure 2-1. However, Fuchslocher et al. went one step further and dressed the avatar in function of their playerbase, teenagers, by giving him a wild hairdo, a T-shirt and jeans, to further maximize identification.

Psychological attributes Likewise physical characteristics, psychological attributes can also be used to have a system establish a presence and allow a user to identify himself with said system. Many scholars have tried to identify and classify all facets of a personality, and yet this is still a heavily discussed topic among psychologists [52]. However, the "Big Five" model has been thoroughly tested and functions as fundamental consensus in the study of personality. Therefore, it could be used by those who design anthropomorphic interfaces for reference. The model consists out of five dimensions listed below.

- Openness: the degree to which an individual is willing to experience new scenarios or is likely to come up with new ideas.
- Agreeableness: sometimes referred to as submissiveness, is the degree to which an individual is likely to help others or to be cooperative.
- Conscientiousness: the degree to which an individual plans his behavior, organized as opposed to easy-going.
- Neuroticism: sometimes referred to as emotional stability, the degree to which an individual is likely to experience negative emotions.
- Extraversion: the degree to which an individual likes to meet and interact with (new) people.

When an interface designer employs these characteristics, one has to keep in mind that a personality, undoubtedly, is more complex. However, the model can be used as starting point. Nass et al. researched people's response to anthropomorphic artificial agents who matched their agreeableness and concluded people's experience is more positive when working with an agent who is psychologically similar [53].

Lin et al. applied this technique in Fish'n'Steps by making the mood of the player's fish a function of the amount of physical activity he performed. Figure 2-3 shows an overview of the three emotional states a fish could have. One can easily recognize the human-like facial expressions used communicate happiness, angriness and sadness. The reflection of the fish' emotional state in function of the player's physical activity is used to persuade him to be more active, as he prefers to see a happy fish. We note the work of Nass et al. [53] and Fogg [49] claim this effect could be amplified by tailoring the personality of the fish to his player. For example, the fish of a rather shy person could blush when his player looks at him for a prolonged time.

Language Fogg states an interface can persuasively influence its user through language, regardless of other anthropomorphic characteristics, or the lack thereof. Oinas-Kukkonen and Harjumaa built further upon his work and presented seven methods, which can be employed to influence in the context of dialogs: praise, rewards, reminders, suggestion, similarity, liking and social role [54]. These techniques will be briefly discussed below.

- Praise: was also mentioned by Fogg, which is in its essence a variation of "well done".

- Rewards: differ from praise through their presentation. Praise is implemented as text, while rewards in the context of dialogs could include animations, for example.

- Reminders: analogous to triggers, discussed in section 2.2.

- Suggestion: recommends the desired target behavior, thereby partially removing the required initiative of the user.

- Similarity: when the system reminds the user of himself, the process of identification, and the persuasive consequences thereof, will be more effective. For example, a dialog system adapted to a user's dialect.

- Liking: the experience a system provides, through both look and feel, should appeal to its users.

- Social role: is not restricted to dialogs, will be discussed below in a broader context.

Social dynamics It is generally known one's behavior is ruled by social conventions. Therefore, these conventions can be used to influence said behavior. Reciprocation, is one such convention a designer might use. For example, an agent, linked to a mailbox, could show the amount of spam mails he filtered out and asks the user in return to smoke one cigarette less that day. Since the agent has done the user a favor, the user in question is more likely to comply with the request made by the agent.

Social roles When an agent adopts a social role, it will also inherit social status and conventions related to the particular role, states Fogg. For example, monitoring software, installed by an employer to supervise his employees, could show a small icon of a police cap in the taskbar while it is running, and would therefore be more easily associated with enforcement of rules.

Oinas-Kukkonen and Harjumaa propose seven techniques to leverage social actors: social learning, social comparison, normative influence, social facilitation, cooperation, competition and recognition. These terms will not be discussed in detail, as they are intuitive. However, we will point out notable discrepancies between them and relate them to Fish'n'Steps. Note all listed techniques use social proof to normalize the behavior [55]. Firstly, social learning and social facilitation are both ways of learning a behavior by perceiving others doing said behavior, the difference lies how this information is presented, either directly or indirectly. During social learning, the learner observes the behavior directly, as opposed to social facilitation, during which the system reports to the learner others are performing said behavior. Secondly, both social learning and social facilitation happen from outside of the group performing the behavior, while normative influence, peer pressure in other words, happens when the learner is part of the group. In Fish'n'Steps, players are socially facilitated by

watching the fish of others grow, and therefore indirectly perceive their behavior, the amount of physical activity they perform. Normative influence is also applied by requiring all players to be physically active in order to avoid blurring the water of the fish tank and keeping the vegetation alive. Lastly, social comparison encompasses competition. Social comparison is defined as any activity during which the learner draws parallels from his behavior to that of others. However, competition requires the behavior be quantifiable somehow. This is needed to conclude who wins and who loses. Fish'n'Steps implements competition, as the size of one's fish can be quantified by the player. However, suppose a player's fish would also change color depending on the type of physical activity performed, say a fish would become more purple if the player had run, and more orange if he had walked, then social comparison is still possible, but quantification, and therefore competition, is not, since there is no objective way to compare the results, i.e. who is to say a smaller purple fish has not been more active than a larger orange one?

2.5 Summary

In this chapter, we reviewed and aggregated literature regarding definitions and taxonomies on serious games. We discussed how the taxonomies related to each other and how they can be integrated into a single overarching model. Subsequently, we thoroughly discussed the work of Yee on in-game motivators in MMORPGs, thereby answering *which motivational game elements typically belonging to large-scale shared-world multiplayer scenarios lend themselves well to be implemented into serious games of similar concept and scale?* Firstly, each motivator was discussed individually by giving a definition and supplying sample implementations in both serious and commercial games. We expanded Yee's socializing motivator by integrating the work of Chen and Duh [33] and subdivided the customization motivator into cosmetic and functional customization. Thereafter, we constructed a graph model which shows how the motivators relate to one another, to be used for analysis of games or exploration of motivational design space. Afterwards, we discussed elements of persuasive

design. Analogously to the discussion about motivators, we discussed all components of Fogg's functional triad. We proposed the use of the Big Five model for creating psychological attributes of social actors and integrated the work of Oinas-Kukkonen and Harjumaa into that of Fogg regarding language and social roles. Lastly, we constructed a model which shows how the discussed elements of persuasive design relate to each other, see figure 2-12. Throughout this chapter, three serious games, namely: Balance, Fish'n'Steps and Logic Gate Puzzler, were analyzed. We discussed how they implemented both elements of persuasive design and Yee's motivators, the latter was also done for some commercial games. This literature review served two purposes: to familiarize ourselves with serious games and with the techniques used to make people want to play them, as it was our intend to create a serious game of our own to gather evidence regarding the potential of large-scale shared-world multiplayer experiences.

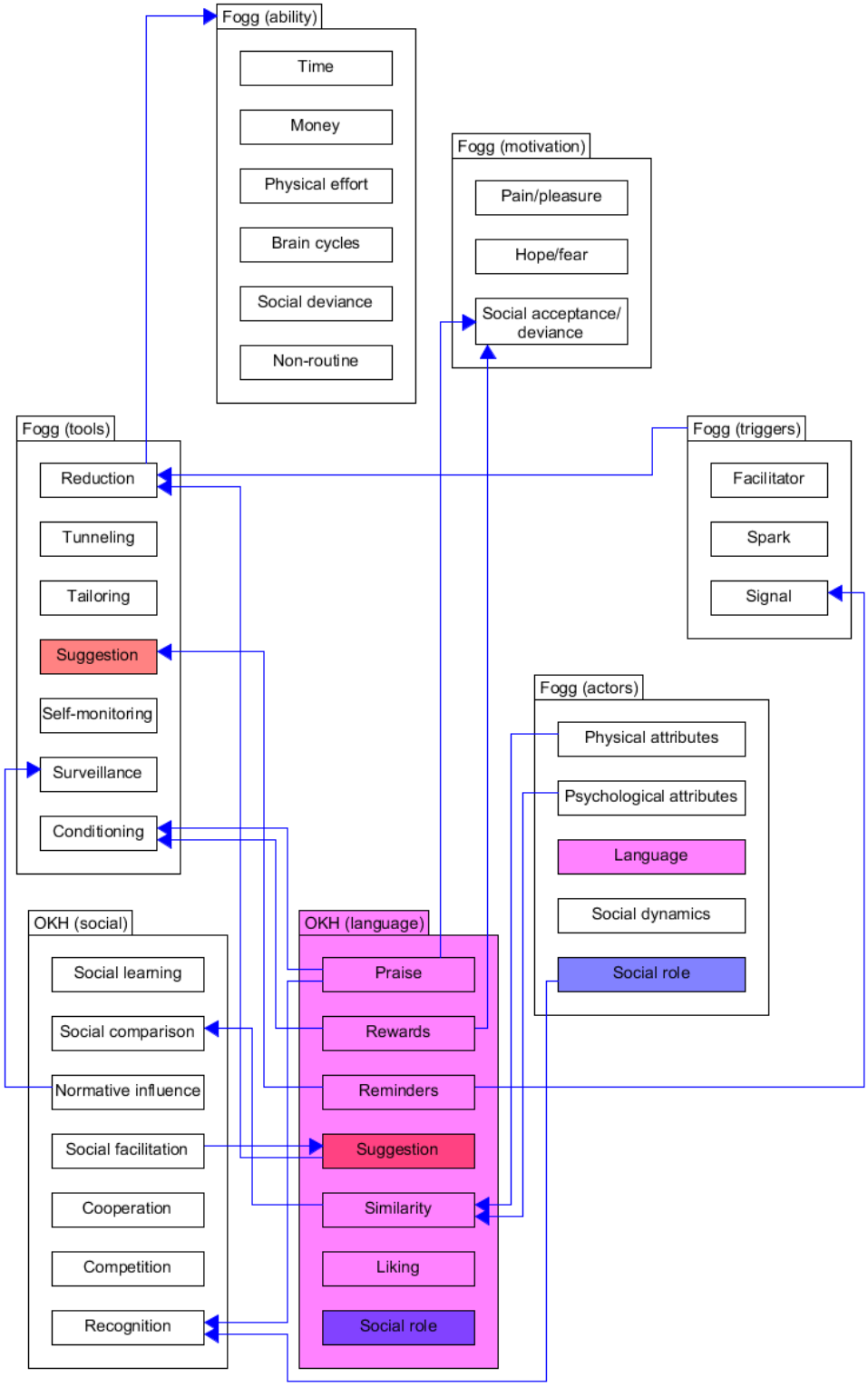


Figure 2-12: An overview of how elements of persuasive design relate to each other. An arrow form component A to component B is used to denote component A can be seen as a form of component B. Similar terms, although used in different contexts, have been given the same color.

Chapter 3

The concept of MOMG and design choices

In this chapter, we will discuss the concept of the serious game we created, MOMG or Movement-Oriented Multiplayer Game, to research the potential motivational influence and design space of motivational elements of shared virtual worlds. We start by describing the target audience and their sedentary habits; thereafter, we introduce the general concept of MOMG. Lastly, each design choice we made during the design of MOMG, either from a game design perspective or a persuasive perspective, will be discussed.

3.1 Target audience and use cases

Most office workers spend a significant amount of their weekdays sitting at their desks, taking only sporadic breaks, for example: to transport office documents, get beverages, or utilize sanitary infrastructure. Additionally, some individuals continue this lifestyle on weekends. This sedentary way of life has been shown to have a negative impact on one's health [56, 57]. One literature review by Thorp et al. summarizes 48 studies and concludes that sedentary behavior consistently increases the risk for premature mortality caused by CVD-related (cardiovascular disease) diseases in both men and women, as well as the risk for diseases such as diabetes and some site-specific

cancers among other health risks [58]. Although some of the selected studies suggest their results are independent of physical activity performed in leisure time, there are still many health benefits to be gained from a physically active lifestyle [59]. Although preventing diseases, and thereby obtaining additional qualitative life years, should provide one with enough motivation to be physically active, there are many people not engaging in one. Surprisingly, even in a rehabilitation context, where people are recovering from a disease possibly caused by their foregoing sedentary lifestyle, it is often noted by physicians that their patients do not perform the prescribed amount of exercises or generally be more physically active. This noteworthy phenomenon where people who have yet recently suffered greatly because of their lifestyle are still not willing to change it, suggests that additional motivational methods are to be used to prevent rehospitalization. In this context of motivating one to perform a target behavior or changing one's habits, serious games are often employed.

3.1.1 Personas

To aid in the design of MOMG, we created three fictional personas, as introduced by Cooper et al. [60], to concretize our users. We list them in this section as they also provide the reader with a generic profile of potential users.

Sarah

Persona:	Senior Employee
Job:	Employed at an accounting firm.
Fictional name:	Sarah
Demographics:	Age 45 - 55, likely to be living together/married.
Goals/Tasks:	Installs the app because an increase in physical activity is part of treating her back pains. Expects the app to manage this process of health improvement (by keep track of her progress, setting goals and giving reminders).
Environment:	Social: Has none to few friends also using health related apps. Physical: Below average due to years of sitting at an office desk. Technological: Below average knowledge: has a smartphone but rarely uses it for other purposes than calling and texting.
Quote:	"I hope this app can help me get rid of these back pains."

Eric

Persona:	Generic Student
Job:	Student
Fictional name:	Eric
Demographics:	Age 18 - 23, unlikely to be living together/engaged. Very unlikely to be married.
Goals/Tasks:	Installs the app out of curiosity. Expects to be entertained by the game. Considers the improvement of his health as added bonus.
Environment:	Social: Has some friends also using health related apps (potential for competitive and social motivators). Physical: Average, moving between classes but sitting during lectures. Technological: Above average knowledge: uses smartphones and apps daily and without any difficulty.
Quote:	"This game looks fun."

Tim

Persona:	Junior Graduate
Job:	Software developer
Fictional name:	Tim
Demographics:	Age 24 - 28, possibly living together/engaged/married.
Goals/Tasks:	Installs the app because he wants to improve his health. Expects game motivators to ease the "burden" of having to improve his health.
Environment:	Social: Has none to few friends also using health related apps. Physical: Below average due to stress and working overtime (sittingly). Technological: Greatly above average knowledge: uses smartphones and apps daily and without any difficulty.
Quote:	"I hope this app can keep me motivated to improve my physical health."

3.1.2 Scenarios

Personas help system designers model their potential users. Caroll's scenarios can then be used to describe how these personas will interact with the system, this interaction depends on their goals and context [61]. In this section, we will supply the reader with two scenarios, related to the described personas, we used to model user-system interaction.

Sarah's experience

Sarah has been an accountant for over 15 years at AccCorp. Her jobs involves integrating a client's paperwork into some accounting application. In general, Sarah spends virtually all 8 hours working while sitting at her desk. The last few months of sitting have been hard on her back. She has spent some weeks at home because of this issue and has been advised to either change profession or be more physically active during her time at work. Sarah opts for the latter and took initiative to install our mobile phone app despite not being up-to-date with technology. The first instruction

had been easy to understand: take 100 steps. This simple task aided in making clear how the user interface needed to be interpreted.

At the beginning of each day, some moment in the morning, the app would set a daily goal. The daily goal always consists out of a number of steps Sarah would have to take and would be calculated by some function of her activity in the last few days. During the day, Sarah would sometimes check this goal to see if she is keeping up. Furthermore, she expects the app to notify her if she has been sitting for too long. Such a scenario had played out last Monday. Sarah had been sitting and working for 2 hours consecutively, from 14:00 to 16:00. The app noticed this and decided to give Sarah a quest which required her to take 200 steps within the next 15 minutes. She read the notification, finished up her current task and walked to the toilets at the other side of the building. Sarah's back pains have greatly lessened after using the app for some weeks. However, she has been advised to keep up her increased physical activity on a daily basis. The effectiveness of the pain as motivator has significantly decreased and has been replaced by in-game motivators. Although the importance of motivators has shifted, Sarah's goal as to why she is using the application is still the same.

Eric's and Tim's experience

As a junior software developer, Tim spends most of his weekdays sitting at his desk. Additionally, he spends a fair portion of his free time also in front of his computer at home. He is aware that his sedentary lifestyle is unhealthy and wants to perform more physical activity to combat this behavior. However, Tim has never been active, let alone sportive. To him, performing tiring physical activity is a burden. This is why he has looked into our mobile app and decided to give it a try. He hopes the app will be able to provide him enough motivation to become and stay physically active. Initially, the discovery of the app is the motivation his curiosity feeds off.

Tim has improved his physical health after some weeks of using the app. At the end of the day, after having had dinner, he uses the app to check how much physical activity has yet to be performed to reach his daily goal. Subsequently, he

goes on a walk around his apartment block proportional to the amount of steps he still needs to take. One day, to his surprise, he achieved the most steps of all users for that day. The app complemented him on this. From that day on, he sets this as his daily objective. Some days later Eric creates an account. Eric is not much into physical health, however, sometimes he installs mobile apps out of curiosity and to be challenged. Due to Eric's student lifestyle, which is much less sedentary compared to Tim's, his physical condition is similar to Tim's improved condition. One day, Eric sees the challenge of becoming the one who takes the most steps a day. That day, he dethrones Tim and satisfies his need for competitiveness while doing so. Tim is caught by surprise when he notices he is no longer number one at the end of the day. When looking over the daily step board, he sets himself a new goal for tomorrow: retaking first place.

3.1.3 Brief concept of MOMG

MOMG is a multiplayer game, played on a smartphone, which aims to increase the amount of physical activity its player perform by applying motivating techniques from gamification and persuasive design. A beneficial side effect of playing MOMG is players becoming more aware of their physical habits. By this definition, MOMG is categorized as a serious game (see section 2.1), classifying as preventative and therapeutic, depending on the user's context, in the taxonomy proposed by Sawyer et al., seen in figure 2-4. The game is two-dimensional, viewed by players from an angled top-down perspective, see figure 3-1. Unlike many other serious games, all MOMG-players share a virtual world. This shared virtual world opens up an array of motivators (discussed in section 2.3), especially Yee's social motivators, discussed in section 2.3.2, which would be difficult to implement in a traditional singleplayer serious game, and the social persuasive techniques discussed in section 2.4.1.

Each step a player takes in real life, by walking around or by running, is rewarded with one golden coin in-game: i.e. a player's physical activity determines his in-game wealth. With the earned currency, the player can buy objects to populate the shared virtual world. Furthermore, players can complete eight different quests of

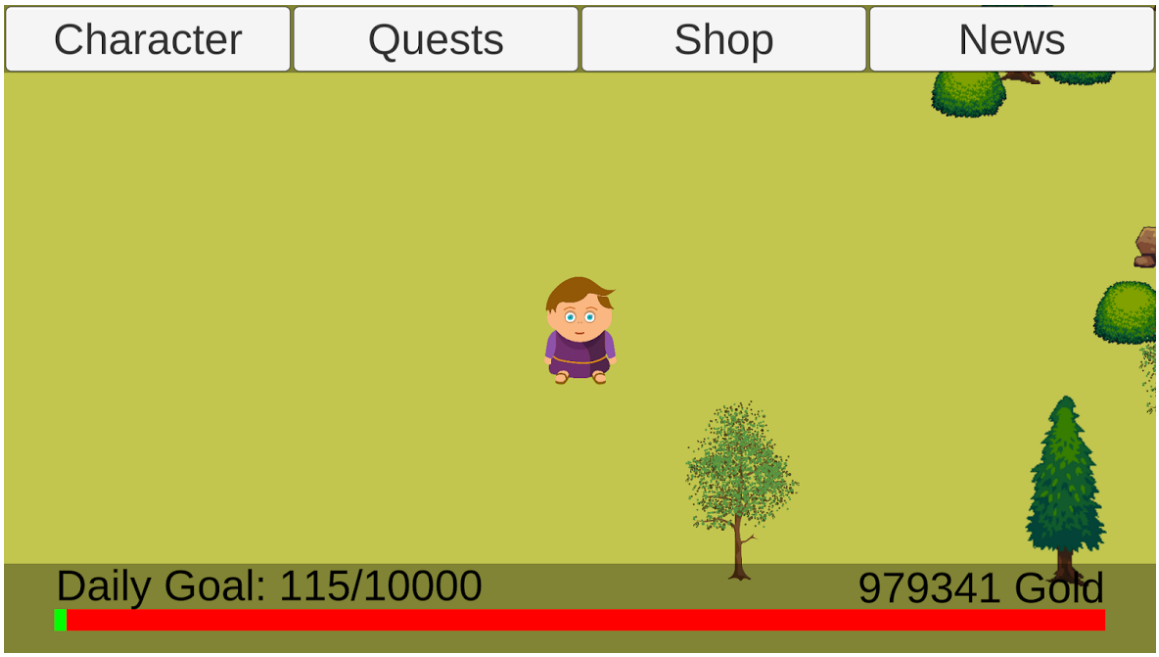


Figure 3-1: The two-dimensional world of MOMG, as viewed by players from an angled top-down perspective.

three different types, resulting in a quest space of 24 possible quests. Completing these quests unlocks purely cosmetic head and body sprites, to be used by the player to customize his character. All quests require physical activity to be performed. Every day the player can also complete his personalized daily goal, which requires him to take a certain amount of steps. This goal is calculated at the beginning of each day and is a function of the goal of the previous day, taking into account the fact whether the player did or did not achieve said goal. During the day, players receive a personalized so called "status report", denoting their achievements of the previous day. An in-game newsfeed can be accessed to view the accomplishments of oneself and others.

3.2 Game design

In this section, we will discuss the motivational game mechanics implemented in MOMG. For each mechanic, a detailed description will be given as well as be classified under Yee's motivators. References to a particular technique or motivator will be

capitalized and written in bold, e.g. **Yee: Competition**.

3.2.1 Quests

A quest in MOMG is a task which requires the player to perform physical activity. A quest could be one of three types: personal, competitive and group. Personal quests can only be seen and completed by the person who owns the quest, while competitive quests can be seen by everyone and be completed by only one person, the player who completes it first. Group quests can be seen by everyone and everyone's steps count towards the shared objective. When a group quests is completed, the whole group, even those who contributed nothing, get a reward, while personal and competitive quests reward only one player. Every step taken by a player automatically counts towards all ongoing quests that player has, including any group quests. Since quests are handed out by the system, the player is not burdened with making them up (**Fogg: Reduction**) and can access an overview of tasks he could complete, classifying as **Fogg: Suggestion**.

There were eight different quests, all included at least one variable, X, the amount of steps required, while some more complex quests contained up to three variables. An overview of the eight quests and their variables is given in table 3.1. To understand the eight different quests, it might be conceptually easier to think of there being only two quests: Walk and Run quests, while Interval and Timed are modifiers possibly applied to these two abstract quests. The Interval modifier adds one variable to the quest, named S, and now requires the amount of steps, be it walking or running, to be taken within a time frame of S seconds. The Timed modifier also adds one variable, T and requires it to be completed before that point in time, essentially putting a deadline on the quest. Thinking of quests this way, there being two abstract quests, to which two modifiers can be applied, we end up with eight possible quests since no modifiers, one modifier, the other modifier and both modifiers could be active for an abstract quest. Consider the examples below, one example per type of quest:

- A group Walk quest with $X = 30000$ requires the sum of steps of all players to

reach 30000 steps.

- A competitive Run Timed quest with $X = 2000$ and $T = T_{current} + 21600$ requires the player to be the first one to run 2000 steps before six hours (21600 seconds) have passed.

- A personal Walk Interval quest with $X = 1000$ and $S = 900$ requires the player to walk 1000 steps within 15 minutes, i.e. there need to exist two points in time, spaced 900 seconds apart, within which the player walked at least 1000 steps.

Type Name	**Description**	**Variable Count**
Walk	Walk X steps.	1
Walk Interval	Walk X steps within S seconds.	2
Walk Timed	Walk X steps. Expires at time T.	2
Walk Timed Interval	Walk X steps within S seconds. Expires at time T.	3
Run	Run X steps.	1
Run Interval	Run X steps within S seconds.	2
Run Timed	Run X steps. Expires at time T.	2
Run Timed Interval	Run X steps within S seconds. Expires at time T.	3

Table 3.1: Overview of the eight different quests.

Quest rewards

Completion of a quest was rewarded in one of two ways: the player either unlocked a random body sprite or a random head sprite. Both sprites can be seen as cosmetic items used by players to customize their characters. It was guaranteed the rewarded sprite was not already unlocked by that player at an earlier moment, avoiding the disappointment the player would face, should he be given a duplicate sprite, and thereby ensuring quest completion was experienced positively. Whether the player would unlock a head or body sprite, was shown in the quest interface, as seen in figure 3-2. Players could unlock a total of 11 head sprites and 8 bodies sprites. The goal of this reward scheme on a short term basis, is to make them perform more physical activity, while in the long term applying **Fogg: Conditioning**, as being physically

active is associated with rewards, hence the rewards are randomized to strengthen this effect.

This reward scheme incorporates four motivators. Firstly, unlocking a sprite classifies as **Yee: Achievement**, since it enlarges the player's collection of sprites, further progressing that collection. Furthermore, the amount of sprites collected, serves as a status symbol, influencing **Fogg: Social Dynamics** and yielding **OKH**[1]**: Recognition**, as it denotes the amount of quests the player completed, and therefore, the amount of physical activity he must have performed doing so. We must remark here that, in general, performing physical activity is socially encouraged in Western culture, as physical activity is correlated with being healthy and linked to the ideal body shape, pushed by virtually all media. This observation shows Fogg's behavior model supports the motivational aspect of this game mechanic, as the behavior yields **Fogg: Social Acceptance**. Secondly, the player might be motivated by the ability to further customize his character, if the unlocked sprite was one he desired. This motivator classifies as **Yee: Customization**. Consequently, customizing one's character enables **Yee: Role-playing, OKH: Social Comparison** and claiming an identity in the virtual world, classifying as **Yee: Socializing**. Furthermore, a player customizing his character has two additional socially persuasive implications. Firstly, through customizing one's character, the player normalizes the completion of quests, thereby, stating the behavior, and consequently the required physical activity, is socially accepted, further encouraging it through **OKH: Social Facilitation**. Secondly, as over time more avatars will be customized by their players, remaining players who have not yet unlocked at least one head sprite and one body sprite, will be socially pressured due to **OKH: Normative Influence, Fogg: Social Deviance**.

Inherent quest motivators

Quests themselves, without regard to the reward upon completion, also mainly tie into **Yee: Achievement**, as their completion is analogue to ticking an item off a to-do list, a satisfying experience by itself without the quest reward. This analogy

[1] "OKH" is short for "Oinas-Kukkonen and Harjumaa".

Figure 3-2: The quest interface showing which quests are available, what they entail and their rewards.

makes sense as the quest listing is essentially a list of tasks a player is expected to do. Furthermore, the quest system, to a lesser degree, also incorporate **Yee: Mechanics** and **Yee: Discovery**, since both require the player to interact with the quest system to gain information about how it functions. **Yee: Mechanics** might motivate people to complete quests to see how the system responds to them completing quests, as to further analyze that response in an attempt to gain an advantage, e.g. a player completing mainly easy quests, hoping the system would automatically create new quests of this difficulty level. **Yee: Discovery** might push a player to complete all his quests to see what is next, if, for example, he would be offered a special reward for completing all quests. The motivators discussed in this paragraph are applicable to all quests types: personal, competitive and group.

Competitive quests were meant to incorporate **OKH, Yee: Competition**. The competitive aspect would come forth out of the fact only one player could complete a given competitive quest, and consequently only one player would get the reward. For our user experiment, see chapter 5, we took two additional decisions to further enhance the competitive aspect. Firstly, we made competitive quests always reward

body sprites, which were rarely rewarded from personal or group quests. This allowed for directed **Yee: Achievement** and for competitive players to earn **OKH: Recognition** through owning many body sprites. Secondly, the competitive quests were generally easier to complete, i.e. requiring less steps, compared to most other quests (**Fogg: Reduction**). Since competition is a powerful motivator, we designed half of competitive quests as run quests to try to persuade players to go running.

Group quests were meant to incorporate **OKH: Cooperation, Yee: Teamwork** and their completion to elicit a feeling of group achievement. The goals of this type of quests were chosen to be very difficult to virtually impossible to be achieved by one player, as they required several tens of thousands of steps. Therefore, completion of group quests required a contribution, in the form of steps, from several players. Additionally, two other socially persuasive motivators could come into play during group quests. Firstly, **OKH: Normative influence, Fogg: Social Deviance** could socially force players to contribute to the group quest or risk being alienated by the group. Secondly, since every player receives a reward upon completion of the group quest, a player who contributed only a small amount of steps might feel the need to reciprocate through **Fogg: Social Dynamics**. Interestingly, players might try to motivate others to contribute to the group quest, as to lower the amount of steps they themselves would have to take (**Fogg: Reduction**). This effect could have been leveraged more if players would have been able to see each other's contribution towards the shared goal.

Designing group quests was difficult, as the amount of step the group of players would take, was difficult to predict. In a scenario of eight participants who would be moderately active, say each player taking 7500 steps a day on average, a group quest requiring 50000 steps would be easily accomplished. However, that same quest would be very difficult, and possibly frustrating to some, if the majority of player would only take 4000 steps a day on average. Therefore, we chose to keep the amounts of steps required by group quests rather low. Alternatively, the group quest's goal could also have been calculated by some function of the individual daily goals.

3.2.2 Character customization

A player's character consisted out of two sprites: head and body (see figure 3-3 for an example), both could be customized by the player. As mentioned in section 3.2.1, these sprites were unlocked by completing quests. We chose to reward a randomly chosen sprite as to prolong the lifetime of this motivator, for suppose a player would be able to choose his reward, then he would pick the sprite he desires most and he would be able to create the character he wants to by completing just two quests: one rewarding the head, another rewarding the body. This way, after having created the desired character, a player would have substantially less motivation left to continue completing quests. The same problem would arise if players would be able to buy sprites. Secondly, getting a random reward, much like gambling, excites the player, allowing for more effective **Fogg: Conditioning**, since the reward is not known in advance and thus is always a surprise. However, we note prolonging the life time of **Yee: Customization** this way, could potentially frustrate the player because he might consider a reward not to his likings not as a reward at all. Therefore, we chose to minimize this risk by making sure the system would never reward the player with a sprite he already owned. In total, the player could unlock 11 head sprites and 8 bodies sprites, although, during the user experiment, there would not be enough quests available to unlock all sprites. Initially, all players started with the same head and body. The sprites were purely cosmetic, no additional benefit could be gained from them in terms of game mechanics.

Being able to customize one's character also ties into **Yee: Socializing**. The looks of the player's avatar, one's virtual representation, is an important aspect or tool used by the player to claim an identity. For this reason, the head sprites are different hairstyles in different colors as opposed to the same hairstyle altered by minor hair cosmetics, like hairpins. Since a newly created character has a particular look, the player involuntary communicates he most likely has not yet completed any quests, and might therefore be perceived as inactive or lazy by other players, due to **OKH: Social Comparison**. Players aware of this, will be motivated to complete

Figure 3-3: An avatar is composed out of a head (left) and a body (middle). Together they make up an avatar (right).

quests to be able to change their perception by others, consequently joining the group of customized avatars, escaping judgement due to **OKH: Normative Influence, Fogg: Social Deviance**.

3.2.3 Daily goal

A player's daily goal is an amount of steps the player is expected to take that day, therefore incorporating **Fogg: Suggestion, Reduction** similarly to quests. The goal is personalized and calculated by the system as a function of the player's previous goal and whether he achieved it or not (**Fogg: Tailoring**). The player does not have any input in this process. At midnight, the new goal is calculated by equation 3.1: if the player did reach his daily goal, his new goal is his current goal, increased by 10%, otherwise it is his current goal decreased by 20%. This potential for continuous increase in amount of steps required, was not a problem due to the short-livedness of the user experiment. However, prolonged tests might need to cap the daily goal, since a player is likely to lose motivation when his goal requires an unrealistically high amount of step to be taken.

$$Goal_{new} = \begin{cases} 1.1 * Goal_{old} & \text{if player achieved daily goal the day before} \\ 0.8 * Goal_{old} & \text{otherwise} \end{cases} \tag{3.1}$$

The player's progress on his daily goal is shown in a progress bar at the bottom of the screen, as seen in figure 3-4. Additionally, a textual representation is also given. The combination of these two representations is ideal because of their synergy. The progress bar gives the player an intuitive overview of the normalized progress, while the label accurately shows how many steps have been taken and have yet to be taken. Each of them enables **Fogg: Self-monitoring**. Note progress bars incorporate **Yee: Achievement**, due to their nature.

Lastly, when the player logs on, he cannot avoid being confronted with the progress of his daily goal, possibly making him aware of the lack of progress on the amount of physical activity he is expected to perform. Consequently, a player looking at his progress might function as **Fogg: Signal**.

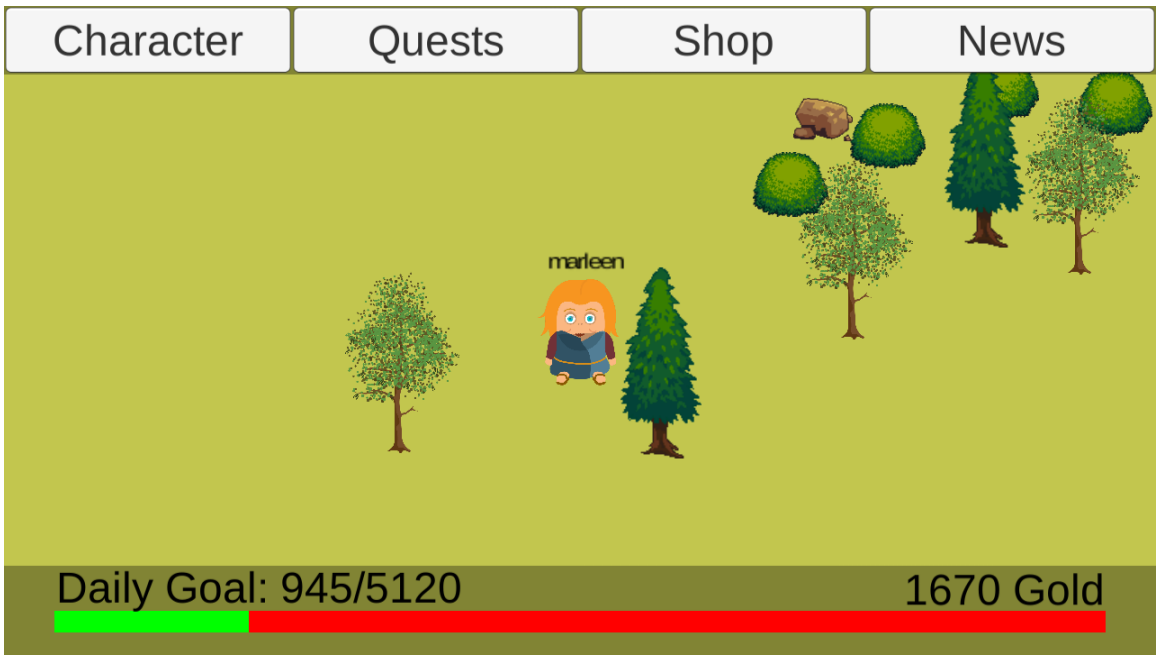


Figure 3-4: The bottom of the screen shows the current progress of the player's daily goal, both graphically and textually.

Daily goal reward

To provide additional motivation, aside for the sake of completion, we decided to reward the player an amount of golden coins upon completion of his daily goal (**Fogg: Conditioning**). The amount rewarded is equal to the amount of steps required to reach the goal, e.g. completing a daily goal of 8000 steps, earns the player 16000 golden coins in total, since each step taken towards reaching the goal, rewards him one golden coin, and the completion awards an additional 8000 golden coins.

3.2.4 Newsfeed

MOMG features an in-game newsfeed of noteworthy events, like many social media. Two types of items are displayed in the feed: the act of completing a quest and reaching one's daily goal. In case of the former, the item includes the description of the quest as well as the type of quest. A daily goal item shows the amount of steps that daily goal required to complete. An item always includes the time the event occurred and an image of the player's avatar. Furthermore, the newsfeed holds the latest 10 events. See figure 3-5 for an example.

Displaying the player's avatar next to his achievements, was a deliberate choice by which two of Yee's motivators were activated. Firstly, because one's character is shown next to the event, completing quests and daily goals can now be used to establish an identity (**Yee: Socializing**) in the virtual world, i.e. the newsfeed functions as a tool for the player to show he is being active, performing the target socially accepted behavior, with their avatar on display to indirectly take the credit for them (**OKH: Recognition**). Secondly, competitive-minded players can use this identity to feel superior to others as the type of quest completed is also shown (**OKH, Yee: Competition**).

The newsfeed also ties into all but two technique of the discussed work of Oinas-Kukkonen and Harjumaa. It enables **OKH: Social Comparison**, since players can compare the difficulty, type and amount of quests they completed to someone else's, and **OKH: Normative Influence**. For an example of the latter, suppose a player

is not listed in the newsfeed, then everyone knows he did not recently complete any quests nor did he reach his daily goal, essentially meaning he does not conform with the group. Hereby, **OKH: Normative Influence, Fogg: Social Deviance** might persuade him to complete quests as to be mentioned in the newsfeed. In addition, the feed can be used by players to indirectly observe others performing the target behavior (**OKH: Social Facilitation**) and, in turn, have their behavior observed (**Fogg: Surveillance**).

Figure 3-5: A screenshot of the in-game newsfeed during our user experiment.

Lastly, from a persuasive perspective, browsing the newsfeed provides a simple activity, requiring virtually no ability in Fogg's terms, as it can be performed by only tapping twice when the app has started (once to login and once to open the feed), and might allure players this way to logon.

3.2.5 Building

Players could populate the shared virtual world of MOMG with objects bought using the golden coins they earned by performing physical activity. Therefore, this game mechanic is a second implementation of **Yee: Customization**. In total, 13

objects could be bought, including houses, trees, bushes and cats. The objects we chose to implement were everyday objects, and therefore known by every player, and easily allowed the construction of a whole, as opposed to bark and leaf tiles, for example, which players would have to combine themselves to get a tree. A complete overview of available objects and their price is shown in table 3.2. Notice how the price range can be divided into three categories: inexpensive objects (trees, bushes, tiles, stones and pillars), moderately expensive objects (houses and the black cat) and expensive objects (the tower and the white cat). All bought objects tie into **Yee: Achievement** and **OKH: Recognition**, as they serve as status symbols, especially objects belonging to the latter price category, and thus could be used to perform **OKH: Social Comparison**. Although this building mechanic was not specifically designed to stimulate **Yee, OKH: Competition**, it could be used this way. For example, players could challenge each other to plant the most trees in a line. Likewise, the mechanic allows for **Yee: Teamwork, OKH: Cooperation**, but no other mechanics encourage this behavior. Additionally, having a shared virtual world enables two more social principles which stimulate building. Firstly, a roaming player could encounter another player building. This encounter encourages the activity through **OKH: Social Learning**. Furthermore, we initially populated the world with a path, surrounded by trees, from the spawn point to a tower, see figure 3-6. We hoped this would show players the possibilities of combining simple sprites as well as encourage building through **OKH: Social Facilitation**. Secondly, when a player has bought none to few objects and notices most others players have, he would be motivated to build by **OKH: Normative Influence**. Lastly, players were able to sell the objects they placed for 95% of their respective purchase value.

Finally, having a shared virtual world has another major advantage over single-player worlds. It allows for endless **Yee: Discovery**, as players are continuously changing the world by building. In addition, an open virtual world also enables **Yee: Escapism, Role-playing**, however, we did not design for these motivators.

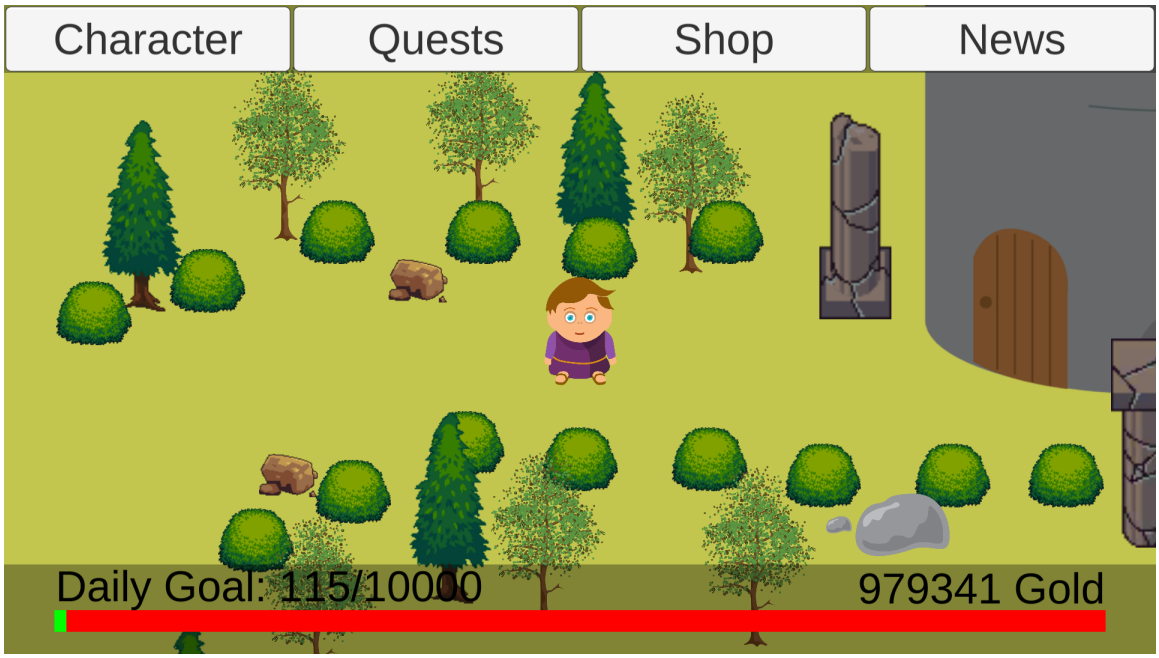


Figure 3-6: Objects present on the server when our user experiment began.

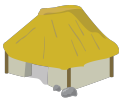
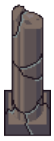
Description	Price	Image
A tree	200	
A tall tree	200	
Some stones	50	
A big stone	100	
A small house	4000	
A medium-sized house	6000	
A big tower	10000	
A tile of a path	100	
A bush	350	
A damaged pillar	500	
A damaged pillar	500	
A black cat	5000	
A white cat	20000	

Table 3.2: A scaled-down overview of the objects players could buy.

3.2.6 Status reports

The system sent each player a personalized so-called "status report" during the first half of our user experiment via e-mail. This system was implemented Wizard-of-Oz style, i.e. a researcher would look into the server logs and compose the e-mail. Since participants often had similar progress, phrases in the mail were reused between users and over days. This would make it seem like the e-mails were composed by an algorithm. Additionally, the mails were kept short and to the point, and were sent between morning and midday. See mail 3-1 for an example.

The first sentences of the mail gave the player an overview of the past day regarding quests. They stated how many quests the participant completed, including their type, and would sometimes refer to the unlocked rewards. These sentences were meant to provide the user with a sense of achievement (**Yee: Achievement, OKH: Recognition**) through **OKH: Praise**. Furthermore, the mail informed the player of the quests unlocked that day (**OKH, Fogg: Suggestion**). The middle part of the mail reported the player's progress towards his daily goal. It stated how many steps the player took (**Fogg: Self-monitoring**) and how many his daily goal required. It then stated the consequences, either the amount of steps required for the daily goal of that day would be decreased or increased, depending on the fact the user failed or succeeded respectively. The last part of the mail encouraged the player to achieve his daily goal and quests, possibly mentioning the associated rewards.

```
Good morning Sarah,

    You unlocked a head yesterday by completing your first quest!
    Well done! Today, two additional quests have unlocked for you to
    complete. You did not reach your daily goal of 8000 steps, you
    only took 2115 steps. Because of this, we lowered your daily
    goal for today to 6400 steps. Don't forget you get an additional
    6400 golden coins for completing it!

See you tomorrow!
```

Mail 3-1: An example of a status report.

Chapter 4

Implementation

The realization of MOMG, from a technical perspective, will be discussed in this chapter. We will look into the workings of both client and server applications, their data exchange strategies and the most notable technical challenges hindering the implementation. Particularly sections on the latter will serve as "lessons learned" and might result in a significant time gain for those who wish to implement a similar concept.

4.1 Architectural application design

The concept of MOMG is realized by the combination of three entities: a pedometer, a game client and a game server. The pedometer is networked and uploads the user's steps periodically to the game server. The game client connects to the game server, receives the current game state and changes the game state by sending updates regarding the player to the game server. The game server handles these two types of clients: it receives and stores the amount of steps a user took as reported by the pedometer, while also sending the current game state to connected game clients and handling their responses.

4.1.1 Client applications

Both pedometer and game client were designed to be present on the smartphone of a player. We chose not to implement the functionality of both into a single application in order to be able to use different technologies. The pedometer was a java app, while the game client was made using Unity.

Pedometer

Since step detection was not the focus of this work, we used an off-the-shelf approach. The step detection was done using an algorithm, extracted from two classes from a GitHub project named "privacy-friendly-pedometer"[1]. When the pedometer detected a step, it recorded the force measured by the accelerometer at that very moment and added it to a list. When this list counted five items, they were reduced to a tuple (A, T) where A is the average, weighted equally, of the five forces, previously recorded by the accelerometer, and T the current UNIX timestamp, rounded down to seconds. These tuples were stored in another list, ready to be uploaded to the server. This reduction, from five measurements to one, was done for two reasons. Firstly, to smoothen out the reported forces, as these can vary widely within a very short time span, and secondly, to reduce the amount of information that would need to be stored in the memory of the smart device and be uploaded at some later point. The latter is important in a scenario where users have limited mobile data plans. The averaged force would be used by the game server to distinguish between walking and running. During experimentation with the pedometer, we first tried to make said distinction in function of the amount of steps a person would take per second on average, reasoning a running person would take more steps per second on average compared to a walking person. However, we were unsuccessful in making the distinction reliably this way. We suppose people do not take more steps per second on average, but take larger steps while running.

Whenever a time-acceleration pair was recorded, the pedometer tried to contact

[1] See `https://github.com/SecUSo/privacy-friendly-pedometer`

the game server. If he succeeded, all recorded data pairs were uploaded and erased from the device's memory. We chose to allow for steps to be stored in memory, while the application did not have an internet connection available, as to not require the user to have a mobile data plan, since he could upload his steps whenever he wanted using a Wi-Fi network, and to not force users who do have a data plan to have it continuously enabled so the device's battery can be saved. Another persistence technique was implemented to ensure the pedometer would start after the device had rebooted, avoiding unthoughtful user being disappointed by their steps not being recorded. This implementation still allows for the scenario where a user would shut down his device, or the battery would die, and lose all steps not yet uploaded. While this risk could have been mitigated by periodically writing uncommitted steps to persistent media, we chose not to, as to reduce complexity of the pedometer. Instead, we pointed this issue out to our users at the start of our user experiment.

For future projects, we would advise to look into third party APIs which allow tracking of physical activity. Google Fit is one such an API. It can track various kinds of physical activities, including walking, running, swimming and cycling. Although it is not perfect, it is more thoroughly tested compared to most off-the-shelve solutions.

Game client

The game client was a stand-alone Unity application. It periodically sent updates whenever the player was moving his avatar. The client also notified the server which objects the player bought and sold. However, the client first had to log in to the game server. This was done solely through a username, not accompanied by a password. A player's username was his real-life first name. By compiling the game client per user, we were able to hard-code usernames. Therefore, a player did not need to input his username, reducing the login procedure to a single button press and preventing users from logging in to others users' accounts. No additional security measures were taken. When the client connected to the server, it would receive all required data to be shown, e.g. the progress the player had made towards his daily goal, items to be displayed in the newsfeed, quests, placed objects and their locations. All updates

regarding movement of player avatars and the interpolations done, was handled by the Unity networking engine. This and other networking features, such as remote object instantiation, state synchronization and remote procedure calls, are part of Unity's HLAPI[2] and significantly reduced the development resources required to create a networked multiplayer game.

4.1.2 Server application

The game server needed to be able to handle pedometers connecting and uploading step counts as well as game clients connecting, sending updates and retrieving information. We used two ports to allow the server to easily differentiate between the two different types of connecting applications. Pedometers connected on TCP port 8000 while the game client used UDP port 7777. Although using different port numbers was not necessary, since different transport level protocols were used, this was done to allow for the use of Unity plugins which use TCP. The TCP connections made by pedometers were handled using a thread-per-client model. Lastly, the game server was also implemented using the Unity framework.

When a pedometer connected, it first announced the username of the player it belonged to, subsequently, it sent all time-acceleration pairs stored in its memory. This connection was kept open and could be used continuously. The server stored all pairs per user in memory, to be used for quest completion tracking, while the golden coins earned were immediately added to a player's account. Therefore, the server featured the same problem as the pedometer, namely shutting down the server would result in a loss of data. However, the consequences of this risk were limited, since manual intervention could be used to add any arbitrary amount of steps into the system. Note that in case the system would crash or shut down, the already completed quests or daily goals of that day would not be lost. However, we recognize this issue should be resolved when testing on a larger scale, as manual intervention does not scale well. Furthermore, section 4.3.1 describes the degree to which the server was persistent.

[2]High-Level API

4.2 Game assets

Developing games can require many different types of assets, e.g. sprites, models, textures, sound effects, music. We chose to limit MOMG to solely sprites, as we did not have many development resources. In addition, we reason users tend not to use sound in a public context. Most of the sprites were designed by an artist on the team, while others were taken from a website which freely distributed them. In this section, we will discuss four ways game assets can be obtained and which techniques we employed.

Firstly, a dedicated person, such as a graphical artist or sound designer, can be used to create one or more types of assets. As stated earlier, most of our sprites were created this way. While this method may yield the most suited assets, as the content creator can be steered by the development team, it is expensive in terms of development resources. Secondly, assets can be obtained through websites which distribute them. They can be freely available, often licensed, or require to be bought. Unity's Asset Store[3] is one example of a website offering both free and paid assets. Other initiatives, such as Open Game Art[4], solely provide free assets and were used to obtain complementary sprites. A downside of this method is that the assets will most likely not exactly match that what is desired. Thirdly, procedural algorithms can be used to generate content. This technique is often employed to create assets which can be relatively easily described in terms of parameters for some known algorithm, such as terrain generation, described in section 2.3.3. While this method allows for the creation of thousands of assets in a short time span, it might not result in much variation, depending on the complexity of the algorithm. Lastly, existing assets can be altered through filtering to create new content. We applied this technique ourselves to create recolored hairstyles, see figure 4-1.

[3]See `https://www.assetstore.unity3d.com`
[4]See `https://opengameart.org`

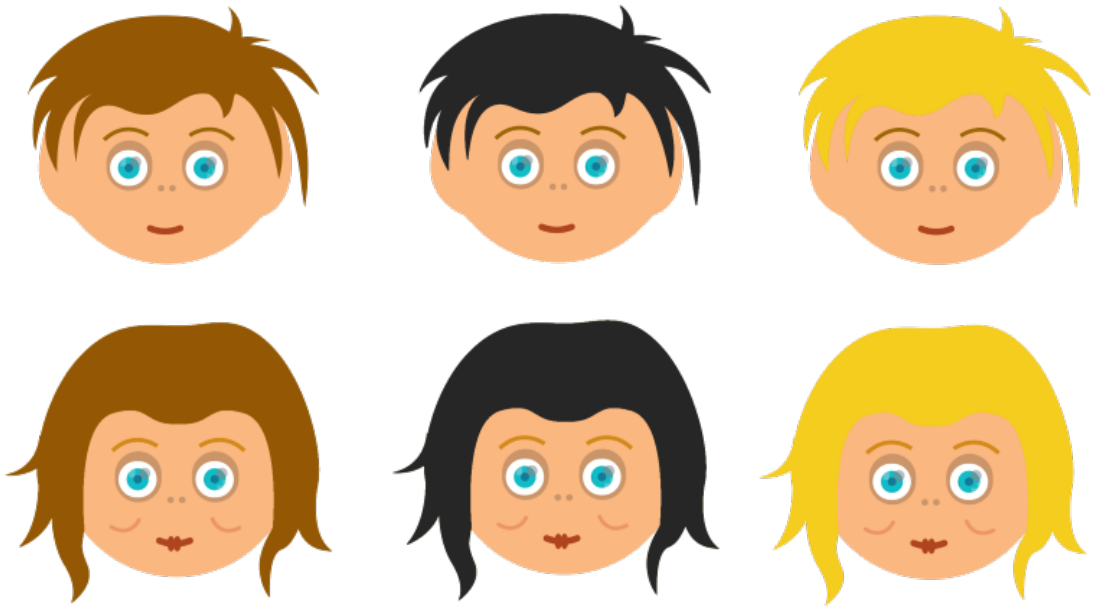


Figure 4-1: Some of the head sprites we created by means of recoloring.

4.3 Technical challenges

In this section, we will discuss several technical issues we encountered while implementing and testing MOMG. These difficulties range from efficient quest completion tracking to detecting and handling half-open TCP connections. Each issue will be discussed followed by how it was solved or can be taken into account.

4.3.1 Server persistence

Server persistence was implemented to prevent data loss should the game server fail due to a system crash or power failure. Periodically, every 60 seconds, the server binarily serialized all important data structures from memory to disk. In hindsight, it would have been better to serialize the data to XML because it would simplify manual intervention. In .Net, and many other frameworks, serialization can be easily accomplished using the built-in serialization features. Whenever the game server started, it looked for the serialized data and loaded it. If no files were found, the server defaulted to a starting configuration. The serialized game state was backed up

using Dropbox[5].

4.3.2 Efficient quest completion tracking

Pedometers collected tuples and sent them to the game server. These tuples were of the form (A, T) with A being the average force over five steps, as measured by the accelerometer, and T the UNIX timestamp of the fifth step rounded down to seconds, as discussed in section 4.1.1. The game server kept these tuples in a sorted list, per user, and periodically, every 60 seconds, ran a quest completion algorithm on them to check if any quest had been finished. Note all tuples of a given user could be easily sorted by their time stamps since the pedometer uploaded them chronologically, unless the user would change the clock on his smart device. During the implementation of the server, we tried to keep the complexity of the server low and thereby attempted to avoid the use of additional threads, as to limit the amount of concurrency issues possible. However, this design required all operations on the main server thread to be short-lived. Since each quest needed to be checked per user, we made sure the quest completion tracking algorithm could be run in $O(n)$, where n is the amount of tuples. This was especially important when checking group quests as n, the sum of all tuples over all users, would be of a higher order. The chronological aggregation of all tuples of all users was done using a generalization of the merging step part of the MergeSort algorithm. In this step, two sorted lists are combined into a newly sorted list. Our adaptation allowed for an arbitrary amount of lists to be merged this way. All algorithms described further in this section, depend on the assumption the tuples were sorted.

Simple Walk and Run quests could be easily checked. Firstly, make a copy of the user's tuple list and name it L. Secondly, depending on the objective, keep or remove all tuples (A, T) from list L, where $A < P$ with $P = 13.5$, the run threshold value. Thirdly, if $length(L) * 5 \geq X$ then the quest is completed, where X is the amount of steps required to finish the quest (see section 3.2.1 for a discussion on the types of quests and their variables). Timed Walk and Timed Run quests are also checked this

[5]Dropbox is a file storage system hosted in the cloud.

way with the addition of a test on their expiration dates which compared them to the current date and consequently removed them if they had expired. Interval quests were more difficult to check efficiently. Remember these quests could be phrased as finding two points in time, spaced S seconds apart during which at least X steps were taken. Therefore, we needed to check all maximal possible sublists where the first tuple and last tuple are spaced no further apart than S seconds in time. Algorithm 1 illustrates how this was accomplished efficiently. Lastly, note all of the algorithms described above can be executed in $O(n)$ time, where n is the amount of tuples.

Data: list of tuples L, amount of steps required X, time interval S in seconds
Result: A boolean indicating if tuple list L contains an interval of maximally S seconds within which at least X steps were taken.

```
Algorithm TookXStepsWithtinWindowS(L, X, S)
1   if length(L) == 0 then
2       return false;
    end
3   start = 0;
4   stop = SlideWindow(L, 0, 0, S);
5   while true do
6       range = (stop − start) + 1;
7       if range ∗ 5 ≥ X then
8           return true;
        end
9       else if stop == length(L) - 1 then
10          return false;
        end
11      else
12          start ++;
13          stop = SlideWindow(L, start, lastStop, S);
        end
    end
Procedure SlideWindow(L, start, lastStop, S)
1   while lastStop + 1 < length(L) AND
    L[start].time_stamp + S > L[lastStop + 1].time_stamp do
2       lastStop ++;
    end
3   return lastStop;
```

Algorithm 1: The algorithm used to check an Interval quest for completion.

4.3.3 Hardware and software heterogeneity

Heterogeneity in hardware and software stacks made development significantly more difficult than expected. One example of the former, heterogenic hardware, we encountered was a difference in accelerometer implementations, which would affect the pedometer in two ways. Firstly, not all accelerometers would report sensor data when the device was locked, since some implementations would not trigger the events as to prolong battery life of the device. To solve this problem, we used a wake lock. Such a lock forces the device to stay "awake", enabling all components except its screen, and therefore process all sensor events. This solution significantly reduced battery life of the device, one of the most reported negative feedback items. A better solution to this problem is making use of a dedicated built-in step counter sensor. However, as of yet, few devices implement this type of sensor. Secondly, the pedometer would sometimes not count steps due to a significant difference in reported sensor data. Performing the same movement with two devices could yield very different results. Partly, this is to be expected as the data is delivered in a polling fashion, i.e. discretely. However, across accelerometer implementations this variance resulted in some devices not properly registering steps. This issue can be solved by implementing an initial learning period during which the user walks around while the application automatically determines a calibration function in software, an additional filter, to normalize the reported sensor data.

Heterogenic software stacks also caused problems during development. Firstly, Android requires applications to request permissions before they are able to use certain features. For example, the pedometer created a wake lock and thus required `android.permission.WAKE_LOCK`. Permissions are requested through their presence in the application's manifest. The exact permission needed for a certain feature might differ between versions. Android newest version, Android 7, even requires some permissions to be granted by the user at runtime in addition to being present in the application's manifest. Secondly, behavior of API calls might also differ between Android versions, they might even become bugged. One notable example we encoun-

tered was a name resolution system call which leaked a file descriptor. Remember the pedometer periodically tried to contact the game server to report any steps taken, therefore requiring an IP-address to connect to. Hardcoding an IP-address, however, has the downside of having to update the pedometer if our ISP[6] changed said address, hence we registered a domain. This domain would then be resolved by the application through DNS[7] to an IP-address. This approach mitigates the problem described earlier. However, after many hours of debugging, we eventually noted that the name resolution module in one Android version would leak a file descriptor if the smart device did not have internet access. Depending on the amount of steps taken by the user, the pedometer would try to resolve the domain in order to connect to it, this would periodically leak a file descriptor. After 1024 file descriptors were leaked this way, the kernel would not allow the application to open a new socket, thereby preventing the steps from being reported.

Lastly, we remark that developers can use emulators to test for the effects of heterogeneity in software stacks. However, this process is very time consuming since the emulation layer is often, depending on the hardware of the host, not able to run in real-time and additional development is required to feed spoofed sensor data into the emulator.

4.3.4 Half-open connections

Since the pedometers used TCP connections to upload step tuples to the game server, an interrupted connection would be noted by them due to a lack of TCP ACK packets. Should this happen, the pedometer closed the socket associated with the connection and tried to reconnect. This resulted in many so-called "half-open connections" at the side of the server. The term is used to refer to desynchronized socket states at one side of the connection. Their existence is problematic as they consume resources, especially for servers as they are not rebooted often. Although many operating systems support periodically sending keep-alive frames on behalf of the application, this approach is

[6]Internet Service Provider: a company which supplies its customers with internet access.
[7]Domain Name Service: a protocol used to map domain names to IP-addresses.

not guaranteed to work [62]. Therefore, we implemented a feature into the server which periodically sent a one byte long dummy frame to the pedometers. If the TCP stack of the server threw a timeout exception, the server would know to close the socket, thereby preventing half-open connections existing for a prolonged period of time.

Chapter 5

User experiment

In this chapter, we will discuss the user experiment we conducted to evaluate the motivators and elements of persuasive design implemented in MOMG. Seven participants played MOMG on a daily basis for one week. All participants were familiar with smart devices and apps, five of them at least held a bachelor's degree in computer science. Each participant was asked to fill out a pretest questionnaire. The results hereof will be discussed in section 5.2. The setup and progression of the experiment itself is discussed in section 5.3. Feedback was gathered using a posttest questionnaire filled out by all participants one day after the weeklong experiment had ended. Two weeks later, the feedback was discussed individually with each participant during an interview. The posttest feedback is discussed in section 5.4. Finally, the user experiment is summarized in section 5.5. Note that all conclusions we will draw, are qualitatively inferred due to the low amount of participants. We start this chapter by briefly discussing a foregoing pilot study.

5.1 Pilot test

We conducted a pilot test for five days which ended two weeks prior to the start of the user experiment. The aim of the pilot test was to ensure MOMG worked correctly on a technical level, to evaluate the test procedure, as well as to ensure the user friendliness of the user interface, in particular if the information displayed by

the interface could be easily perceived and interpreted. The pilot test counted two participants: the MOMG developer and an involved researcher. Both used MOMG for five consecutive days. The quests used during the pilot test, shown in table 5.1, differ from those used during the user experiment. The initial daily goal was set to 8000 steps. Before the start of the pilot test, the pretest questionnaire (see appendix A) was mailed to the participants and filled out. During review of this questionnaire, one additional question, question 5, was added regarding which version of Android a user's smart device ran.

The feedback gathered at the end of the pilot test proved the test to be meaningful. We noted that battery saving modes/apps hindered the pedometer and made sure this was pointed out at start of the user experiment. Several user interface controls, such as buttons and labels, were increased in size to make them easier to read and tap on smaller screens. In general, overall consistency of the user interface was improved. Some visual bugs regarding wrongly displayed text in the newsfeed and quest rewards were fixed. The amount of unlockable head and body sprites were respectively increased from 3 and 3 to 11 and 8. One pilot participant remarked that navigation in the game world was difficult due to the lack of reference points, since the initial world was a blank canvas, and suggested displaying a map to resolve this issue. However, this feature was not implemented due to a lack of time. We did, however, populate the server with objects which could be used as reference points, as seen in figure 3-6. Visual quest progression was another suggested feature which was not added due to its implementation being complicated by the game server's software architecture and the limited time available to process the feedback.

Type	**Description**	**Reward**	**Availability**
Personal	Walk 100 steps.	Head sprite	At start of pilot
Personal	Run 1000 steps.	Body sprite	
Competitive (Interval)	Walk 500 steps in 10 minutes.	Body sprite	
Group	Walk 4000 steps.	Head sprite	
Personal (Interval, Timed)	Walk 1000 steps in 20 minutes. Quest expires at midnight.	Body sprite	One day after start
Group	Run 2000 steps.	Head sprite	
Personal (Timed)	Walk 250 steps. Quest expires at midday.	Head sprite	Two days after start
Competitive (Interval)	Run 1000 steps in 15 minutes	Head sprite	
Personal	Run 1000 steps.	Body sprite	Three days after start
Group	Walk 15000 steps.	Head sprite	

Table 5.1: An overview of all quests during the pilot test.

5.2 Pretest questionnaire

We asked all seven participants to fill out a pretest questionnaire (see appendix A) two days prior to the start of our user experiment. The goal of the questionnaire was to acquire insight into the sedentary behavior of the participants, their sporting habits as well as their familiarity with games. Henceforth, we will reference a particular participant using p_1 through p_7. Out of seven participants, six were between 20 and 24 years old, p_6 was 57 years old; three were female: p_1, p_3 and p_6, therefore, four were male: p_2, p_4, p_5 and p_7; five held at least a bachelor's degree in computer science of which p_1, p_2, p_4, p_5 pursued a master's degree and p_7 was employed as HCI[1] researcher, while p_3 studied kinesitherapy and p_6 was a retired elementary school teacher. The Android versions used by their smart devices varied widely: Android 4.3, released in 2013, was the oldest version used by only p_1 while three other participants used Android 7.1.1, the latest version as of yet. Lastly, we note all student participants needed to study for their exams during the experiment. This, as mentioned by some participants themselves, lowered their amounts of physical activity performed.

5.2.1 Familiarity with games

Out of seven, five participants indicated they play games on mobile devices at least once per week. Most polar was p_1 who played games on her mobile device twice per day on average, totaling between 4 to 8 hours per week, as opposed to p_5 and p_7 who never played mobile games. The remaining participants, including p_6, played 1.5 times a mobile game per day on average, totaling at 97.5 minutes per week. Notably, in our sample, the more participants would play games on their mobile devices, the less they would on non-mobile devices, and vice versa. Therefore, we concluded all participants were familiar with games, their input modalities, common game mechanics and systems in general. Furthermore, their familiarity with mobile devices greatly simplified the deployment of the applications. Finally, as part of the pretest questionnaire, we asked all participants to rank Yee's motivators, discussed

[1] Human-Computer Interaction

in section 2.3, according their personal preference as to what they experience to be motivating or enjoy. The results to this question are aggregated in figure 5-1. The figure was obtained by transforming an averaged 1 to 10 point scale to a continuous $[0, 10]$ interval. Fortunately, participants indicated they preferred motivators MOMG focused on, such as **Yee: Discovery, Achievement, Competition**, while also disliking, relatively, motivators MOMG did not focus on, such as **Yee: Relationship, Role-playing**. Although, **Yee: Customization** scored rather low.

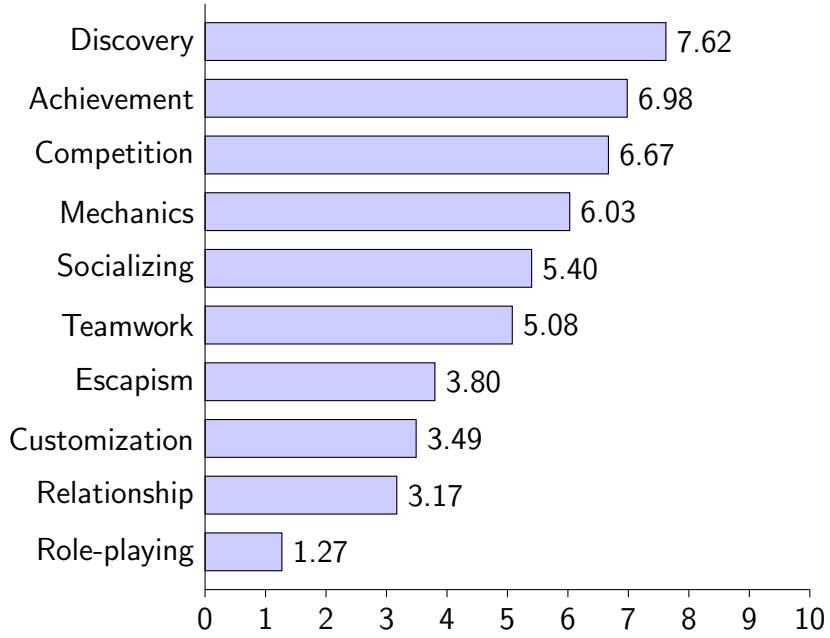


Figure 5-1: A $[0, 10]$ interval showing an overview of average preference towards Yee's motivators.

5.2.2 Sedentary habits

Participants, on average, indicated to sit about 9 hours and 17 minutes per workday. Most polar was p_6, who only sat between 2 to 4 hours per day, as opposed to p_1 and p_5, who sat between 12 to 14 hours on an average workday. On days during the weekend, the overall average only dropped to 9 hours of time spent sittingly. When removing the retired teacher, p_6, from the data set, three out of six participants reported to have to sit between 6 to 8 hours for their work or study, the remaining three reported 8 to 10 hours. During workdays, participants reported to sit for 1 to 2

hours consecutively, averaging at 2 hours and 34 minutes. This average increased to 2 hours and 51 minutes on weekend days. Participants unanimously thought sitting negatively (1/5) impacted their health when asked to rate it on a 5 point scale. All participants, except p_3, indicated to be willing to some degree to change their sitting behavior. Out of seven participants, three, p_3, p_5 and p_7, reported to be already tracking their physical activity, two of them used both a dedicated tracker device and an application on their smartphone, while one participant only used the latter. Sports were performed by four participants at least two times. The remaining three, p_1, p_3 and p_6, did none.

5.3 Setup and progression of user experiment

In this section, we will discuss some of the most notable events which transpired during our user experiment which, as stated before, lasted for seven consecutive days. Quests of the pilot test were reused to a high degree. Some of them were altered: group quests were scaled up to compensate for more participants, and furthermore some minor alterations were made regarding rewards and objectives. Table 5.2 shows an overview of the type of quests, their objectives and their rewards. Several new quests were added as the experiment ran longer than the pilot test. Participants were expected to install the pedometer and game client themselves. The applications were distributed via mail which was detailed with installation instructions and general information on the concept of MOMG. All participants succeeded in installing both applications this way.

One day after the start of the experiment, participants pointed out a cosmetic bug regarding the selection of a head sprite. This issue was resolved that day by distributing an updated version of the game client. Since the game client was to be updated to resolve this bug, we implemented a label identifying one's avatar as requested by several participants, as seen in figure 3-4. Some participants, in particular those with newer versions of Android, also reported that the pedometer would not register their steps correctly. This led to the discovery of the file descriptor leak, as discussed in

Type	Description	Reward	Availability
Personal	Walk 100 steps.	Head sprite	At start of test
Personal	Run 1000 steps.	Body sprite	
Competitive (Interval)	Walk 500 steps in 10 minutes.	Body sprite	
Group	Walk 20000 steps.	Head sprite	
Personal (Interval, Timed)	Walk 1000 steps in 20 minutes. Quest expires at midnight.	Body sprite	One day after start
Group	Run 4000 steps.	Head sprite	
Personal (Timed)	Walk 750 steps. Quest expires at midday.	Head sprite	Two days after start
Competitive (Interval)	Run 1000 steps in 15 minutes	Body sprite	
Personal	Run 1000 steps.	Body sprite	Three days after start
Group	Walk 30000 steps.	Head sprite	
Personal	Run 2000 steps.	Head sprite	Four days after start
Competitive (Timed)	Walk 4000 steps. Quest expires at midnight.	Body sprite	
Personal (Interval)	Run 1000 steps in 5 minutes.	Body sprite	Six days after start
Group	Walk 25000 steps.	Head sprite	
Personal (Interval)	Walk 6000 steps in 2 hours.	Head sprite	Seven days after start
Competitive (Interval)	Run 1500 steps in 20 minutes.	Body sprite	

Table 5.2: An overview of all quests during the user experiment.

section 4.3.3. This bug was also fixed that same day. For some, this resolved the issue of one's pedometer not registering their steps correctly, for others it persisted. Therefore, we allowed participants to report their amounts of steps taken per day to us, as to manually enter them into the system. Often a screenshot of a third party pedometer was supplied as proof.

5.4 Posttest results

In this section, we will discuss the most notable results we inferred. These results led to qualitative conclusions based on the aggregation of three information sources. Firstly, the game server logged events and interactions from clients. Examples include: logging in, completing a quest, buying and selling objects. Secondly, all participants were asked to fill out a posttest questionnaire. The goal of the questionnaire was to obtain general feedback regarding motivators, elements of persuasive design and the

effects on the amounts of physical activity participants performed, i.a. The aforementioned questionnaire can be found in appendix A. Lastly, we conducted an individual personalized interview with all participants two weeks after the test had ended. During an interview, we expanded upon the feedback one gave by filling out the posttest questionnaire. The following subsections will each discuss one particular aspect of MOMG. In the remainder of this section, we give the reader a general overview and context of the participants' activity during the experiment, heuristically assess their interest in MOMG and discuss the mobile internet technologies they used to connect their pedometers and game clients to the server.

Figure 5-2 gives an overview of the amount of steps registered per participant per day. When interpreting this graph, and those that will follow, one must note that on day zero, the day the experiment started, participants had substantially less time to spend on MOMG, since the user experiment started that afternoon. Notice the curve of p_5 and p_7 stays low the first four days of the experiment. This was due to technical problems with the pedometer due to which it did not register their steps correctly most of the time. From the fourth day on, this problem was solved by manually entering their steps; this explains the sudden spikes in their lines in the graph. All participants, except p_6 and p_7, were in their exam periods. Three participants, p_1, p_2 and p_4, noted the amount of physical activity they performed, was negatively influenced by their upcoming exams. This fact can also be inferred from the declining curves of p_1 and p_2 from the third day on. The step count of p_3, the kinesitherapy student, on the fifth day is also notable. Overall, an individual's step count varies greatly between days, depending on their schedule for that day. Lastly, we remind the reader that the amount of steps registered is to be interpreted as a minimum, foremost since one does always carry one's smart device when walking, and secondary, due to the fact the step recognition algorithm worked heuristically.

Figure 5-3 shows the amount of times a participant logged in per day. This graph can be used to heuristically assess a participant's interest in MOMG, and therefore, it gives insight into the novelty factor and its abatement. When not considering day zero, we clearly see that, in general, participants interest declines over time with the

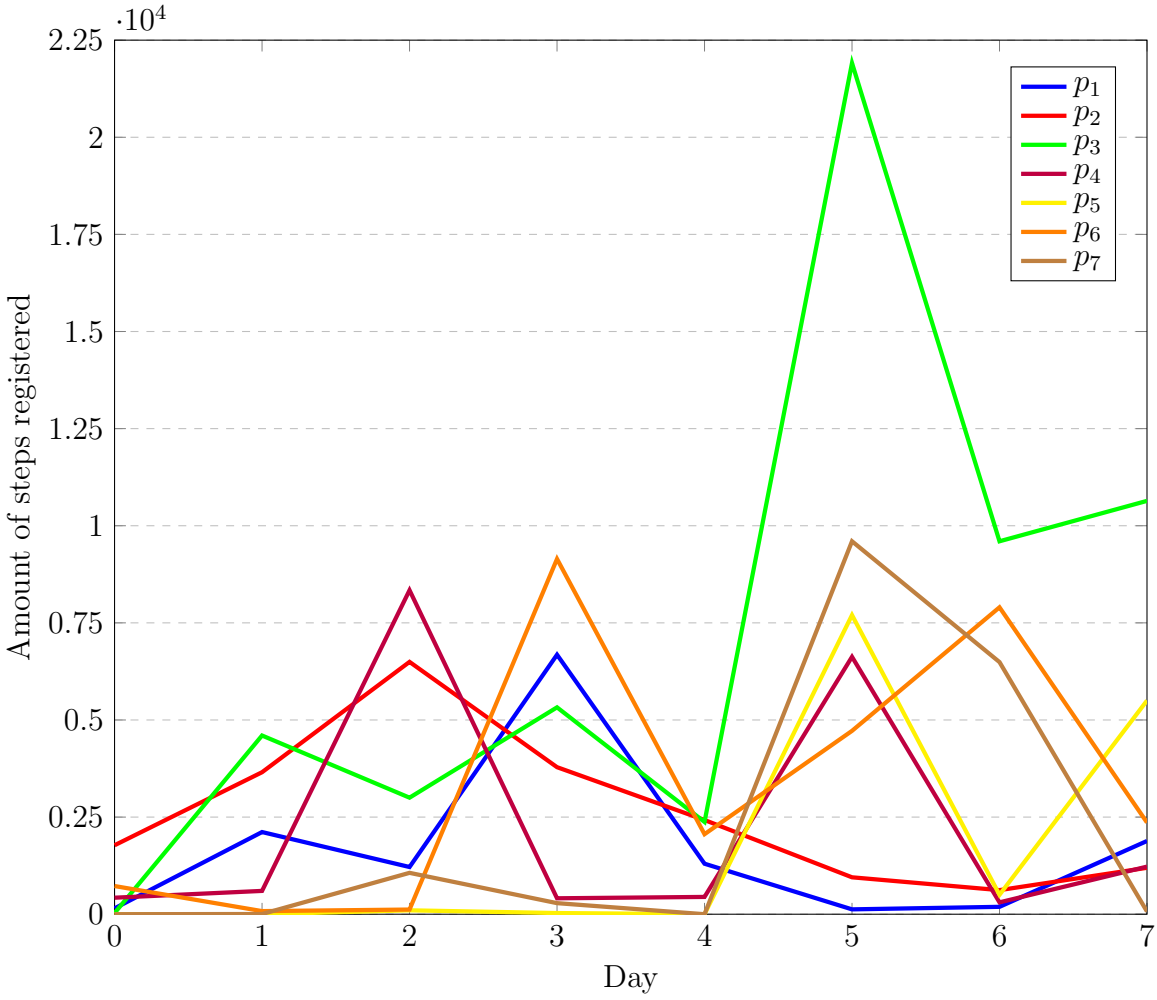


Figure 5-2: An overview of the amount of steps registered per participant per day.

exception of p_6. However, it must be noted that p_6 mentioned during an interview that bad Wi-Fi reception disconnected her game client and that she needed to login repeatedly because of this issue. Nevertheless, the fact she kept logging in, is a sign of interest. Interestingly, participants were asked how often they played MOMG on average per day, and responded 2.36 times on average. We speculate this discrepancy is due to the fact participants interpreted "play" as building or discovering, as opposed to logging in to check one's progress made towards his daily goal or to check the newsfeed.

Lastly, four participants reported using both Wi-Fi and other mobile internet technologies, such as 4G, to allow for communication between the applications and the server. Two participants exclusively used Wi-Fi and only one participant exclusively

used 4G.

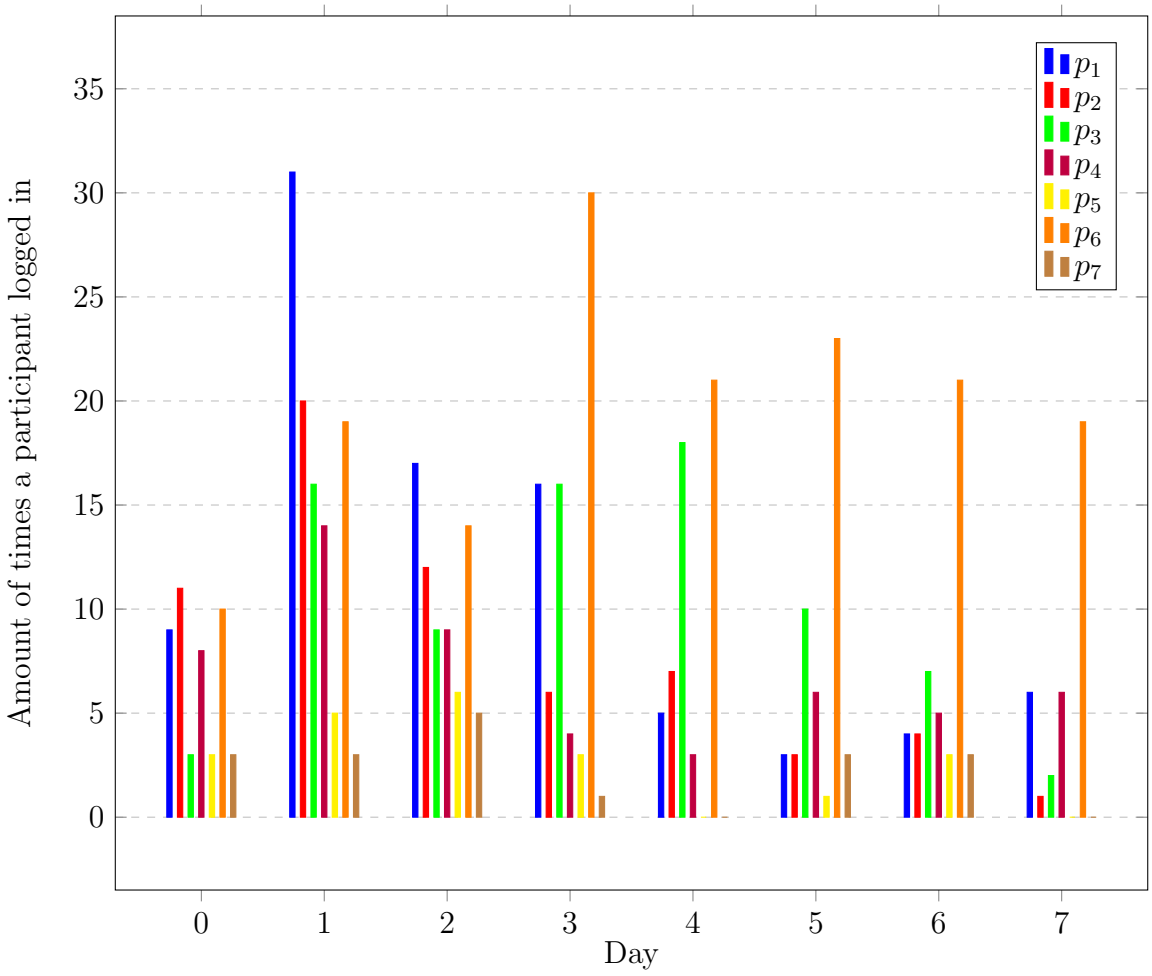


Figure 5-3: An overview of the amount of times a participant logged in per day.

5.4.1 Reception of motivational and persuasive aspects

In this section, we discuss how participants experienced the motivators we implemented, as discussed in section 3.2, the degree to which they succeeded or failed in motivating participants, explanations for why they did so and how their implementations can be improved. We asked participants, analogously to the pretest questionnaire, to rank in-game activities MOMG allows for, according to their personal preference on a 1 to 12 point scale. The averaged results to this question were transformed to a continuous $[0, 10]$ interval shown in figure 5-4. This figure shows a clear preference for building, i.e. buying objects and placing them in the game world, and

discovering what others have built. The following seven activities, starting from *completing personal quests* to *talking to others about MOMG*, score about five out of ten, and thereby, are not preferred to other activities on average. It can be stated of the last three activities, *completing group quests*, *searching optimal strategies* and *escaping daily life*, that they are generally disliked, in particular the latter one. Several explanations, and combinations thereof, are possible for its significantly low score. Firstly, it might be due to the limited amount of content there is to explore. Every day, participants created new content for others to explore by building. However, this was generally not true for all participants. Foremost, some of the additions to one's existing creations would be hard to notice by other players. For example, adding two bushes along a path already encased by bushes, can be easily missed. Another explanation is the fact that playing MOMG required players to spend time performing physical activity, i.e. one needs to walk or run, spend time not playing the game, in order to be able to play the game. These two explanations are the main reasons participants could only briefly play MOMG, and therefore, might not have had enough time to get a feeling of immersion required to escape one's daily life. A third explanation is the lack of avatar animations, since the sprites a player's avatar consisted out of, were completely static. Walking or idling animations, such as blinking, might improve immersion. Furthermore, the art style in general was cartoony, and thus not lifelike. This could also have impacted the game's immersiveness.

We also straight up asked participants why they played MOMG. All participants except p_2 referenced both wanting to perform more physical activity and being interested in playing the associated game, while p_2 indicated to only be interested because of the latter, in particular in the multiplayer aspect. One interesting response from p_3 is worth quoting: "I like being active and also think it is important. Being rewarded immediately by golden coins is far more fun than knowing the real reward is the long term health benefit." Furthermore, p_6 mentioned she was looking for a conventional pedometer application when she heard of our user experiment. She mentioned MOMG seemed more fun than a traditional pedometer. One participant who experienced the pedometer not registering his steps correctly, p_7, remarked he felt a need

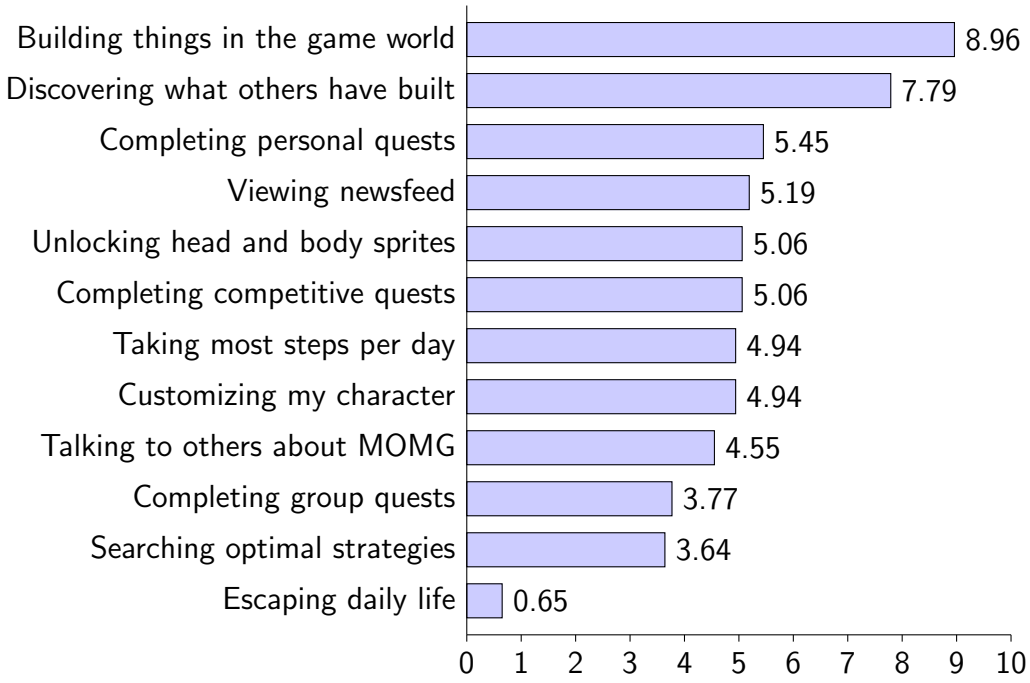


Figure 5-4: A $[0, 10]$ interval showing an overview of average preference towards in-game activities in MOMG.

to play MOMG due to **OKH: Normative Influence**, **Fogg: Social Deviance** and **OKH: Social Facilitation**. He mentioned noticing other participants completing quests, building homes in the game world and wanting to participate in group quests. While only p_7 remarked this, we think without doubt these social persuasive elements have influenced other participants as well.

Character customization

Remember that participants were able to freely customize their in-game avatar by changing its head and body sprites and that these sprites could be unlocked by completing quests. Figure 5-5 shows an overview of the amount of times participants customized their avatar. We notice p_1, p_4 and p_6 customized their avatars the most, respectively, they ranked the activity 9, 11 and 8 on a 1 to 12 point scale. Interestingly, p_1 unlocked only one additional head and body sprite and thus often swapped between the two. Although, this motivator was received positively by three out of seven participants, we believe it harnesses more potential. One explanation for it

being not interesting to the majority, is that only rarely participants would encounter one another in the game world due to their short playing sessions. Therefore, we speculate participants thought few status (**Yee: Achievement**, **OKH: Recognition**) could be gained by customizing their avatars, although one's avatar was shown in the newsfeed.

A second explanation is that the participants simply are not interested in customization in general, as indicated by the pretest questionnaire (see figure 5-1). A third explanation is the simplicity of the implementation. Only two sprites could be changed and they only fulfilled a cosmetic function. The idea of functional item customization will be further discussed in section 6.1.1. Fourthly, during an interview, p_3 remarked that the default head sprite was already the most similar to her, and that therefore, she did not further customize it. Hence, it might be best to ensure that one's starting avatar differs in all customizable aspects from the player's desires. Four participants, including all female participants, reported they tried to make their avatar look like themselves, while only one, p_5, reported his desire to make his avatar as unique as possible. Participant p_1 disappointedly reported that no head sprite was to her likings.

Quest completion

Participants could complete up to 16 quests, including 8 personal quests, during our user experiment, as listed by Table 5.2. Figure 5-6 shows an overview of the completion of personal quests per participant. Most participants completed a fair amount of personal quests, in particular p_4 and p_5, while only p_1 and p_7 completed few personal quests. When confronted with this data, p_1 remarked she thought the rewards, head and body sprites, were not sufficient to motivate her. She added that rewarding special items, for example the expensive white cat (see table 3.2), might have persuaded her. In hindsight, we think our quest system can be improved by allowing quests to reward golden coins, golden coins in addition to a customization sprite or a choice between golden coins and a customization sprite. The low amount of quests completed by p_7, was partially due to the malfunctioning pedometer. He also

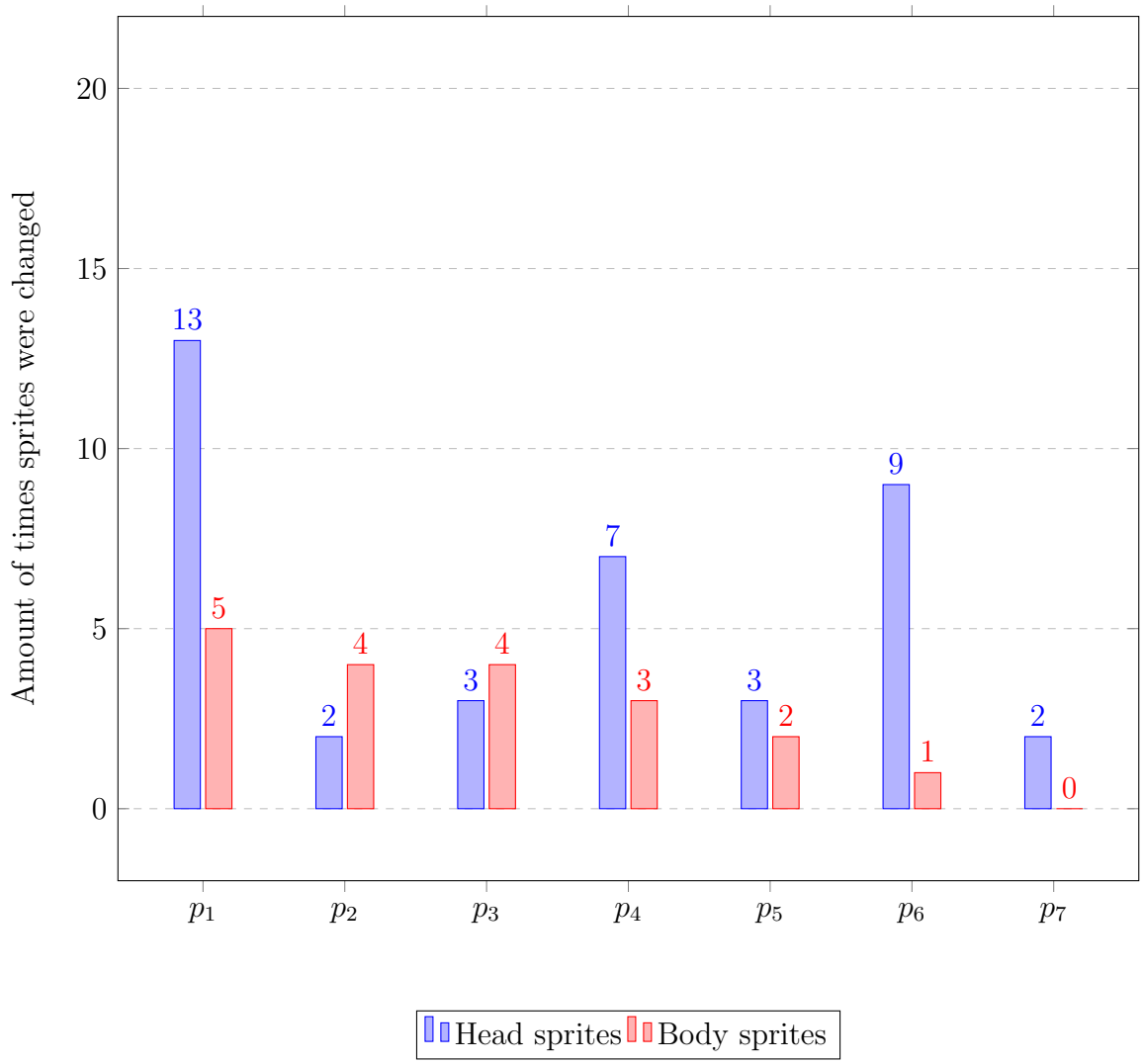


Figure 5-5: An overview of the amount of times sprites were changed per participant.

reported that the weather was a significant factor in his decision making regarding going for a run.

In retrospect, it would have been better to allow for dynamic quest creation by some system which would take into account a player's context, including his daily schedule and the weather, for example. While such a system is difficult to develop, test and refine it might be worth it for prolonged testing. Such a system could further personalize (**Fogg: Tailoring**) the requirements of a quest to an individual's capabilities, allowing for an incremental **Fogg: Tunneling** experience. This is an important feature for a serious game whose demographic varies widely. We learned

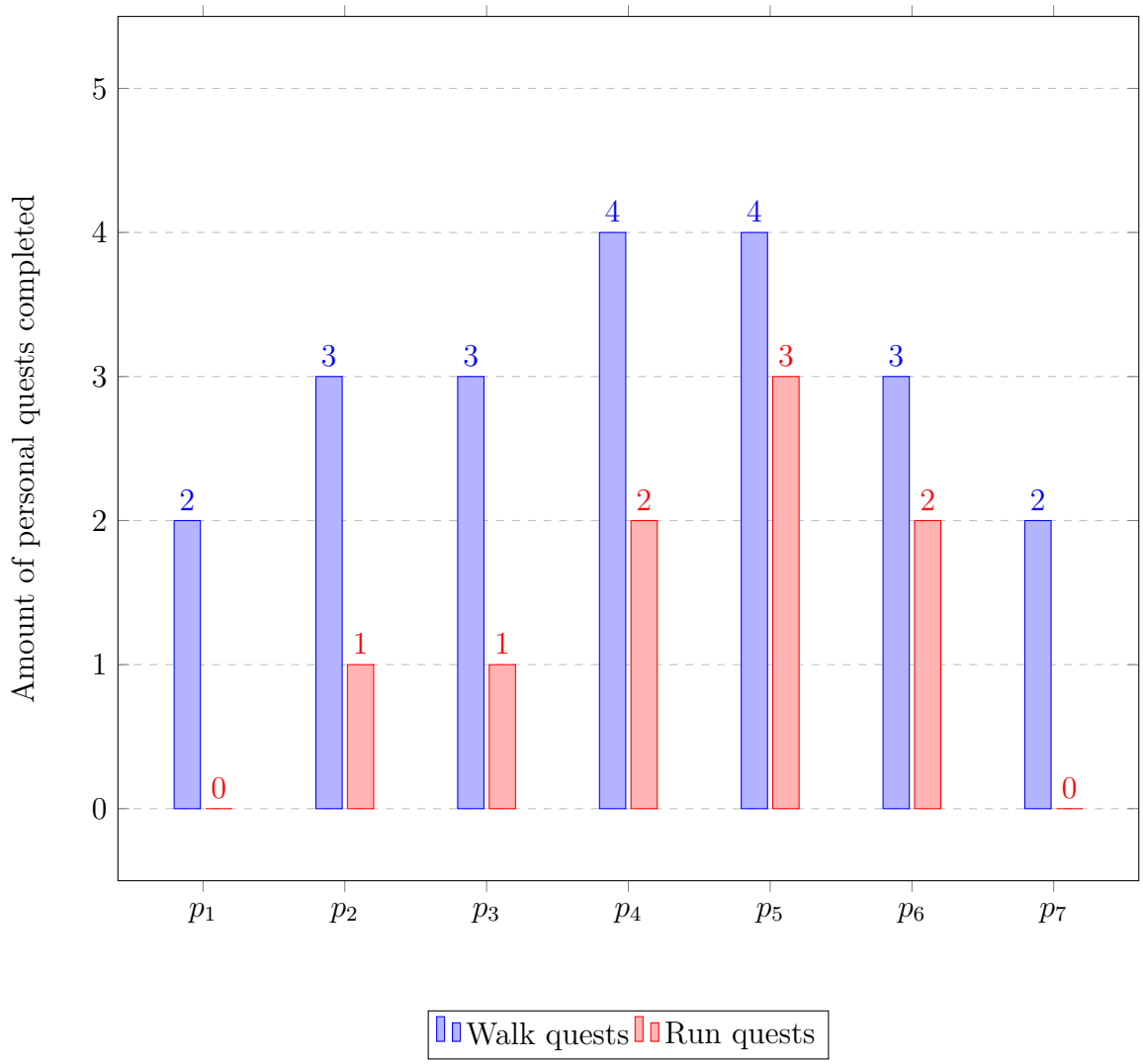


Figure 5-6: An overview of the amount of walk and run quest completed per participant.

this when during an interview, we asked the most active participant, p_3, if she deemed the quests challenging. She responded that she did not consider them challenging but that she liked to be rewarded anyway. Overall, as shown by figure 5-6, difficulty of quests was correctly balanced for the majority of participants, mainly due to the pilot test.

All participants were asked how they prioritized quests and their responses varied widely. Participant p_2 prioritized quests which required the least effort, p_1 and p_3 focused on the ones which they deemed achievable, p_4 and p_6 tried to finish those quests they almost completed during the day, p_5 prioritized them in function of the

sport activities he had planned, p_7 reported he did not prioritize quests. Participants also reported to differentiate between types of quests when prioritizing, two remark to have prioritized group quests, while three reported to have focused on personal quests. Interestingly, not one participant reported to have prioritized competitive quests. Participant p_5 mentions during an interview he thinks the rewards of competitive quests are not significant enough to motivate players.

Competitive quests The fact no participant focused on competitive quests is surprising, since multiple techniques were used to stimulate their completion: their objectives required less effort than personal quests, they awarded body sprites, which were rarely rewarded from other types of quests and their completion was mentioned in the newsfeed. We think the lack of interest for this type of quest, is partially due to participants being tied to their schedule and not be willing or able to change said schedule to incorporate competitive quests. Consequently, participants would give up on them, since they thought they would not be the first one to complete them. Perceived fairness of competitive quests by less sportive participants, might have also impacted their interest. A participant might have thought he stood no chance of completing a competitive quest first, since he is not as sportive as others. Additionally, we think the fact competitive quests did not reward exclusive sprites gave participants the impression they were similar to personal quests and that completing them had no benefit as opposed to completing personal quests. Furthermore, we speculate the lack of exclusive rewards negatively impacted **Yee: Achievement**, **OKH: Recognition** to be gained from completing competitive quests significantly.

Group quests The majority of participants remarked that they would have liked to see their current progress towards a quest, in particular the progress made towards the completion of a group quest, including their individual contributions; this would allow for **OKH: Social Comparison, Social Facilitation**. We think the lack of such a feedback system, is the main reason participants negatively reviewed this type of quest.

Building

Aside from the creative aspects of building and discovery, which are considered inherently fun by **Yee: Discovery**, they are also the easiest way for a participant to show off **Yee: Achievement** and acquire **OKH: Recognition** which in turn enables participants to perform **OKH: Social Comparison**. While this could theoretically also be achieved by character customization, it has the downside of not being possible if a player is not logged in, while one's buildings are always present.

In an effort to gather qualitative evidence to assess the hypothesis that shared virtual worlds can be of value in the context of serious games, we asked participants if they thought the multiplayer aspect, the sharing of the virtual world, was something which added value to their experience, as opposed to each participant having his own world to build in. All seven participants indicated they prefer the virtual world being shared for two reasons: it allowed for discovery of what others had built (1) and it allowed them to show off their achievements (2). This positive response from all participants has led us to believe serious games have much to gain from incorporating a shared virtual world, as it allows for many motivators, including all of Yee's motivators and including all of Oinas-Kukkonen's and Harjumaa's social motivators, to be naturally integrated into the game. Overall, discovery of what others had built, was often quoted during interviews as the most memorable experience. One such example was p_6 mentioning being impressed she had found the expensive white cat p_3 had bought.

In retrospect, the amount of objects available to players to buy, 13, was sufficient for the weeklong experiment. However, prolonged experiments would probably require objects to be added continuously to keep the concept interesting. Other game design problems regarding building were also avoided by the short duration of the user experiment. The list of problems includes running out of space to build and having lingering objects litter the game world. These problems will be further discussed in section 6.1.2. We also learned participants had preferences towards certain sprites and/or types of sprites. To name one example, p_6 started collecting cats once she had

built a home, see figure 5-7. The desire of p_6 to collect cats might be able to motivate her to complete more difficult quests, if they rewarded unique cats.

Figure 5-7: The collection of cats of p_6.

Daily goal

Figure 5-8 shows an overview of the evolution of daily goals per participant in time. If a participant's goal on day $D+1$ required more steps than his goal on day D then that participant achieved his daily goal on day D, hence it was increased the next day. If not, then his daily goal for day $D+1$ was lowered. When looking at figure 5-8, we notice the initial daily goals were set to high for all participants. However, we must remark that we intentionally set the goal on day zero to 10000 steps knowing it would not be achieved, as the experiment started in the afternoon, and therefore would only require 8000 steps the next day. In general, daily goals were less often achieved than expected despite encouragements through the daily mails for the first half of the experiment, in which participants were reminded of the reward if they reached their daily goal.

When participants were asked how they experienced their daily goals, five responded positively, the remaining two did not comment due to the pedometer not

working as intended. Participants p_3 and p_6 reported they liked the fact the goal was personalized (**Fogg: Tailoring**), however p_6 added she feared the goal would be increased the next day to an amount she could not achieve. Participant p_2 noted the initial goal required a high amount of steps and remarked he would have preferred the initial goal to start lowly and increase in amount of steps required over time. When asked if they would have preferred to be able to influence their daily goals, p_3 and p_5 responded they rather have the system set it for them. The remaining five participants remarked they would have liked to have some degree of control over the goal, predominantly to adjust it to their schedule of that day.

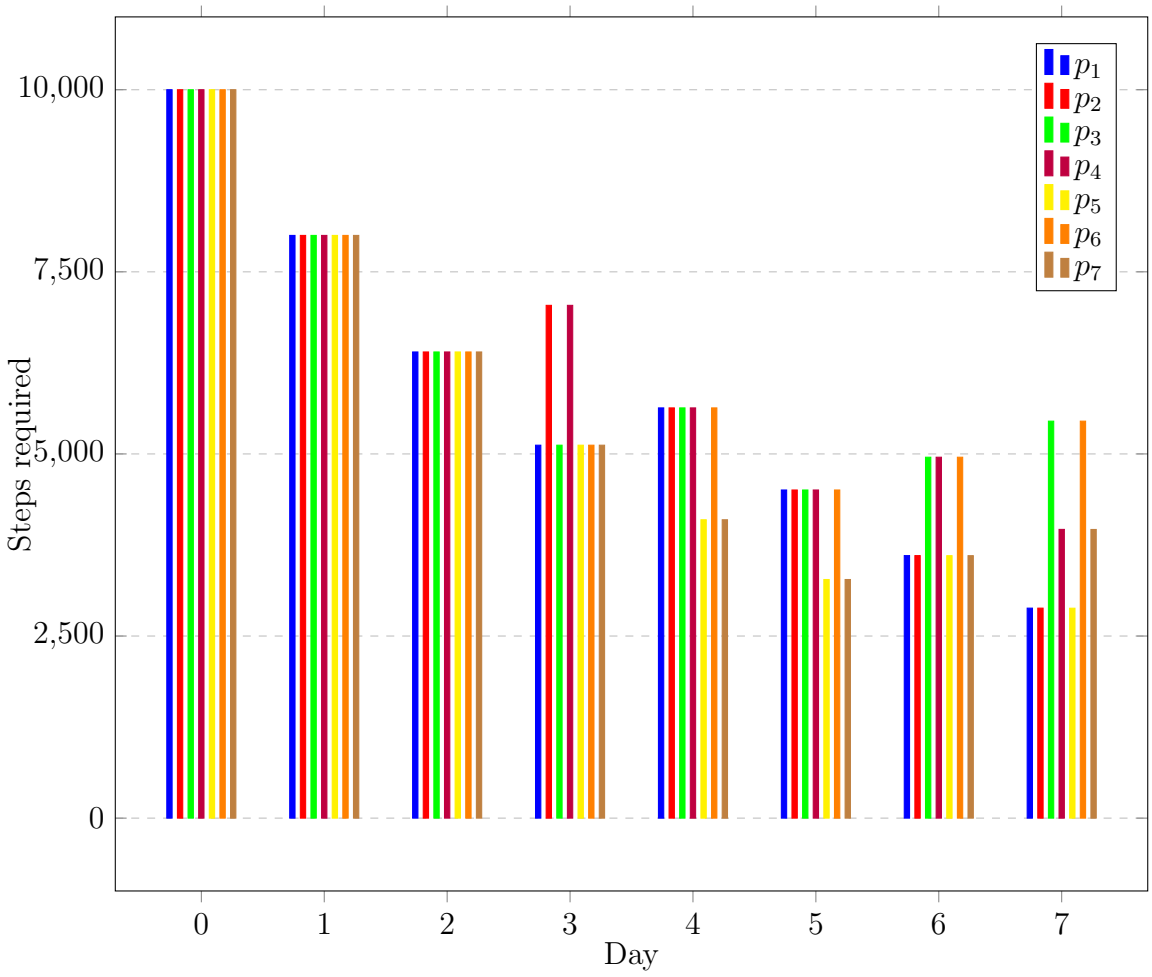


Figure 5-8: An overview of the evolution of daily goals per participant in time.

Status reports

Participants received a status report daily, as discussed in section 3.2.6, during the first half of the experiment. This way, they experienced both conditions and their feedback related to the reports would be more valuable. Participants were asked several questions regarding the daily mails. Firstly, we asked them how they experienced the status reports. Six out of seven participants, all except p_7, responded they experienced them positively. Participant p_7 reported he felt shamed because the mails made it seem like he did not perform much physical activity, due to malfunctioning pedometer. Participant p_3 remarked that the mails were the most motivating aspect to her and p_2 remarked he liked the personalization of the message (**Fogg: Tailoring**). Four participants remarked they felt being watched by the system and that this motivated them (**Fogg: Surveillance**). Furthermore, we asked participants to rate the following statement on a 1 to 5 point scale: *the daily mails (status reports) motivated me to be more physically active*. We averaged and converted the results to a continuous $[0, 10]$ interval, resulting in a 7.86 score. In addition, participants were asked if they missed the status reports during the second half of the experiment. Five out of seven, responded they did, while the remaining two were indifferent. In conclusion of this feature, we think the daily mails were an adequate persuasive tool to motivate participants.

Newsfeed

Out of seven participants, four reported to have checked the newsfeed two to four times per day on average, while the other three participants stated they did so only once per day. Participant p_6 remarked she did so to discuss past events with p_1 (**Yee: Socializing**). In hindsight, the server should have logged this interaction in order to have obtained an accurate amount of times a participant checked the newsfeed. Furthermore, we think it might be motivating to incorporate elements of social media into this feature, such as a like button. One could even allow players to link their game account to existing social media platforms. However, the inclusion of

said feature might not be positively received by everyone. When asked about social media integration, only participant p_4 indicated he might use such a feature, while all six other participants stated they would not.

5.4.2 Effects on physical activity and sedentary behavior

The goal of MOMG was to increase the amount of physical activity performed by a player. Since we did not have data regarding their habitual physical activity nor a control condition, the degree to which a participant's physical activity was increased, was difficult to assess. However, we did ask each participant to assess the increase, if any, themselves. Firstly, participants were asked if they had walked more during the experiment. Only p_7 reported no increase, however, he remarked walking felt more satisfying. The other six participants indicated they walked slightly more than usual, although they could not accurately quantify the increase in physical activity. Participants p_3 and p_4 remarked they would sometimes try to reach their daily goals when said goals were close to completion. Most notably, p_6 reported to have replaced a taxi ride of several kilometers by a combination of walking and bus rides. Participant p_2 stated he would have put more effort into completing walk quests if he had not been in his exam period. Subsequently, we asked participants if they had ran more than usual. Only the most sportive participant, p_3, reported to have ran an additional hour in total, divided into two sessions of 30 minutes. Participant p_5 remarked he thinks his current running habit of running two to three times per week is enough. Of all participants who did not ran before the experiment, p_1, p_4 and p_6, only the latter reported to have done so during the experiment. The discrepancy between these reports and figure 5-6, which reports p_4 completed two run quests, can be explained by the high sensitivity of his accelerometer combined with fast paced walking. Lastly, p_2 states steps taken while running did not yield more golden coins than steps taken while walking, implying running had no advantage over walking in terms of game mechanics when it comes to earning golden coins. Therefore, having awarded multiple golden coins per step while running would have motivated p_2 more, and possibly other participants as well. Thirdly, participants were asked if they had spent less

time sittingly. Although difficult to quantify, all participants but p_7 reported to have at least slightly spent less time sittingly. Fourthly, we asked participants if they had spent less time sitting consecutively. Out of seven participants, four indicated to have do so. Fifthly, participants were asked whether the changes in physical activity were predominantly situated on weekdays or on weekend days. Two participants, p_3 and p_4, indicated the changes were situated on weekends due to having more leisure time available. However, it should be noted that during exam periods, most students do not differentiate between weekdays and weekends, this was also noted by p_4. Lastly, we asked participants to rate the following statement on a 1 to 5 point scale: *I now (after participation) have a better idea of my daily physical activity than before participating.* All participants, except p_3 and p_4, who already used activity trackers, rated the statement at least four points.

5.5 Summary

In this chapter, we first discussed general information regarding participants as well as relevant aspects to their personal context. We qualitatively reviewed our implementations of motivators and persuasive elements, as discussed in section 3.2, offered explanations for the results encountered and suggested how future implementations of the listed motivators and persuasive elements could be improved. Most importantly, in section 5.4.1, we presented evidence to answer: *are large-scale shared-world multiplayer experiences better able to motivate players compared to traditional singleplayer serious games? And if so, does this outweigh the added complexity of designing, developing and testing this type of experience?* The qualitative evidence suggests social aspects of shared virtual worlds are considered more interesting, more motivating, as opposed to singleplayer worlds. In addition, shared virtual worlds allow for social motivators to be implemented naturally, giving serious game designers more motivational options. However, designing, developing and testing these experiences requires significantly more development resources, yet game development has become substantially more accessible due to freeware. Using a high-level toolkit, such as Unity

which abstracts state synchronization, network protocols, hosting, etc., allows for rapid prototyping and development. If not for these tools, creating shared virtual worlds might require too many development resources for academic purposes. Furthermore, our results indicate people will tend to keep to a personal schedule for a given day. The amount people who are willing to deviate from said schedule, differs from day to day, from period to period, and is difficult to assess, since this information can only be obtained from the individual himself and will most likely be irregular due to the individual's responsibilities. The lack of context, in particular personal context, creates difficulties for serious games trying to habitualize new behaviors. In the case of MOMG, this resulted in daily goals and timed quests which would not be achievable due to a player's schedule for that day. Although, it should be noted that no participant reported to feel disadvantaged due to their schedule. Lastly, we conclude individuals who are already sportive seem to be more likely to increase their amounts of physical activity performed compared to individuals who do not sport. A personalized incremental approach might be better suited to stimulate the latter.

Chapter 6

Future work and conclusion

In this last chapter, we start by looking back on some of the suggestions made during the review of our user experiment and discuss in detail how they are areas of future research, while suggesting how they might be solved. Finally, we will summarize our work, including any contributions made.

6.1 Future work

In the area of large-scale shared-world multiplayer serious games, there is much work left to be done. An implementation of such an experience spans many disciplines of which some have not yet been discussed, such as applicational security. Therefore, this section will be used both to further detail issues arisen during our user experiment and issues to come, as well as suggest how motivators might be implemented in future similar projects.

6.1.1 Functional item customization

Remember cosmetic customization was rarely used during our user experiment. The majority of participants would unlock a sprite, take a look at it and decide whether or not they thought equipping the new sprite would make their avatar look more similar to themselves compared to the previous sprite. While this implementation allows for

cosmetic customization of one's avatar, and consequently for better identification, we think customizable functional items might add more enjoyment to the game, depending on the target audience's desire for complexity. In the context of MOMG, functional customization can be achieved analogously to cosmetic customization, by having slots for items to be equipped in. While these functional items might have a cosmetic side effect, their main goal would be to add complexity to the game, possibly enabling other motivators. For example, an avatar might have an item slot for socks, which has no cosmetic effect, and two sets of socks to be equipped in that slot: one pair which yields him an additional golden coin every tenth step he takes while walking and one pair which yields him bonus golden coins for every minute spent running. Aside from the inherent motivational aspect of customization, such an implementation adds complexity for optimal game play (**Yee: Mechanics**) and receiving the latter pair of socks as reward is a form of **Fogg: Suggestion**. It allows for competitive and cooperative players to search new ways to compete or work together and allows for experimentation (**Yee: Discovery**) with the game's rule systems. See figure 2-10 for a detailed overview of the impact on other motivators if functional customization were to be implemented.

6.1.2 Solving game design problems

Some long term game design problems were avoided due to the fact the user experiment lasted only a week. In this section, we will give a brief overview of said problems in the context of MOMG. Each problem could serve as a future project. We would strongly advise to find a solution to the listed problems, at least to some degree, if one wants to conduct a long term user experiment of a concept similar to MOMG. Firstly, as time progresses, the shared virtual world will become populated by player creations. Said creations linger in the game world, taking up space for others to build. While the virtual world could be infinite, its continuous growth would make it significantly more difficult to navigate, for example to go view a friend's creation. Secondly, allowing players to place objects anywhere they want, allows them to grief others by, for example, littering their builds with cheap objects. A solution would

be that players can remove other players' objects if they are located within a certain radius of their home. However, this form of claiming might enlarge the first problem discussed. Thirdly, as participants of our user experiment mentioned, new content, both unlockable customization sprites and objects to buy, are to be added to the game to keep it interesting. We already partially addressed the problem of finite content in section 4.2 and add to that the stalling of progression. For example, by incrementing the price of an object each time it is bought by the player, e.g. the first house a player buys, costs X golden coins, the next one costs $2X$ golden coins... However, the degree to which progression is optimally stalled is difficult to assess. Therefore, trying to find out the minimal pace of progression required to keep a given percentage of players interested, would also make for a valuable future research project.

6.1.3 Applicational security

Both pedometer and game client, as well as the game server, and all protocols used between said entities did not have any security features implemented into them. Therefore, reverse engineering could be used to cheatingly earn golden coins or complete quests. However, this was not a problem due to the short-livedness of the experiment and the trusted playerbase. In online commercial games, however, significant effort is taken to prevent client modifications, bots, etc. Lan et al. argues the lack of detection strategies and mitigation methods hinder development of online multiplayer games [63]. Therefore, research into easily integrable anti-tampering systems is essential for representative testing of large-scale shared-world multiplayer experiences.

6.1.4 Integrating non-player characters

The inclusion of non-player characters, or NPCs, allows for interesting implementations of motivators and elements of persuasive design to be explored. Firstly, an NPC could function as a credible expert on physical activity, giving players pseudo-professional feedback on their habits. The agent could also be used to negotiate a player's daily goal while allowing for more persuasion than a traditional user inter-

face. Secondly, the degree to which NPCs can pass for players, by performing both social interactions and interactions with the game world, can be researched. They would buy objects and supposedly complete quests. Such autonomous avatars can be used at the start of a large-scale shared-world multiplayer experience to give real players satisfactory social interactions, while the playerbase is still growing and would factually not yet allow these interactions to take place. However, designing NPCs to pass as players might only be possible if the social interactions the game allows for, are not complex. For example, when the game allows chatting, player-impersonating NPCs might be easily exposed as artificial agents. This type of NPCs can also be used to allow a player to have a presence even when he is not logged in by giving limited temporary control over his avatar to an agent. This would solve the issue noted by some participants of our user experiment, namely that they seldomly encountered others players due to short playing sessions. A starting point to designing these NPCs, is the work of Fogg regarding social actors, as discussed in section 2.4.1, in particular the section on psychological attributes. Another work of interest is that of Catrambone et al. on anthropomorphic agents [64], which includes a framework to analyze and design said agents.

6.1.5 Evaluation and expansion of motivational graph

The graph we introduced in section 2.3.4, which illustrates how motivators relate to one another, needs to be subjected to future research. Firstly, one could integrate research by expanding components, as we have done for **Yee: Customization** and **Yee: Socializing**, or by adding new components. Secondly, the relations can be qualitatively evaluated, each review strengthening the model. Ideally, one would be able to quantify the inter-motivator relationships. For example, we suppose implementing **Yee: Competition** greatly allows for **Yee: Teamwork** as opposed to **Yee: Discovery** enabling **Yee: Role-play**, however the current model does not indicate this.

6.2 Conclusion

In this work, firstly, we reviewed and aggregated literature regarding definitions and taxonomies of serious games, making a contribution by showing how the discussed taxonomies can be integrated into one another. Subsequently, we thoroughly discussed the work of Yee regarding motivators in MMORPGs [3]. For each motivator, we discussed Yee's definition and elaborated on implementations both in serious and commercial games. We made a contribution by expanding Yee's socializing motivator by the work of Chen and Duh [33] and proposed to subdivide the customization motivator. This discussion served to answer our first research question: *which motivational game elements typically belonging to large-scale shared-world multiplayer scenarios lend themselves well to be implemented into serious games of similar concept and scale?* Subsequently, we contributed a motivational graph which shows the relations between Yee's motivators, including our additions. Furthermore, we discuss and show how the graph can be used to explore motivational design space, how it can serve as tool when designing a serious game and how it can be used to analyze motivational aspects of existing serious games. Our motivational graph answers our second research question: *how can motivational design space be explored?* As we planned on creating an experimental serious game ourselves, to answer our third and final research question: *are large-scale shared-world multiplayer experiences better able to motivate players compared to traditional singleplayer serious games? And if so, does this outweigh the added complexity of designing, developing and testing this type of experience?*, we reviewed and aggregated literature regarding persuasive design, since techniques thereof can often be seen as motivators themselves or be used to explain them. In particular, we discussed Fogg's functional triad [49] and integrated the work of Oinas-Kukkonen and Harjumaa [54] into the categories related to language and social roles of said triad. In summary of this contribution, we contributed a graphlike overview which shows how the discussed persuasive techniques relate to one another. Throughout our literature review of both motivational and persuasive aspects, we referenced implementations by three serious games: Balance [11], Logic Gate Puz-

zler and Fish'n'Steps [12], among commercial examples. Afterwards, we discussed the concept and target audience of our own serious game named "MOMG", which aimed to improve physical activity. We thoroughly discussed how the game's systems and interface implemented the discussed motivators and persuasive techniques. Furthermore, we discussed technical aspects related to implementing a large-scale shared-world multiplayer experience, such as the applicational architecture, the problems we encountered and how they were solved. Finally, we discussed a weeklong user experiment of MOMG. During the discussion, we presented qualitative evidence which indicates that large-scale shared-world multiplayer experiences have potential as serious games. Compared to traditional serious games, they allow for social motivators and elements of social persuasive design to be implemented naturally. While designing, testing and implementing is more difficult for said multiplayer experiences, the increase in development resources can be partially mitigated by using high-level programming languages, tools and engines, which aim to maximize abstraction.

Appendix A

Questionnaires

Questionnaire MOMG (Movement-Oriented Multiplayer Game) - Beforehand

1. **Name and surname**

2. **Email address**

3. **Age**

4. **Gender**
   Mark only one oval.
   - Male
   - Female

5. **Which version of Android do you have installed on your device? (How to find this out: Settings > About phone > Android Version)**

6. **How much time do you spend on average playing games on mobile devices?**
   Mark only one oval.
   - Never
   - Less than 30 minutes per week
   - 30 minutes to 1 hour per week
   - 1 hour to 2 hours per week
   - 2 to 4 hours per week
   - 4 to 8 hours per week
   - More than 8 hours per week

7. **How often do you play mobile games on average per day?**
   Mark only one oval.
   - Never
   - Once per day
   - Twice per day
   - 3 to 4 times per day
   - 4 to 6 times per day
   - More than 6 times per day

8. **How much time do you spend playing games on NON mobile devices on average per week?**
   Mark only one oval.
   - Never
   - Less than 1 hour per week
   - 1 to 2 hours per week
   - 2 to 4 hours per week
   - 4 to 6 hours per week
   - 6 to 10 hours per week
   - 10 to 14 hours per week
   - More than 14 hours per week

9. **Arrange the things listed below regarding playing games from most fun to least fun according to your personal preference.**
Mark only one oval per row.

	Progressing, acquiring power and status	Searching optimal ways to play	Competition, winning	Building personal relationships	Hanging out with others, conversing	Cooperating with others	Explorering	Being able to be someone else, role-playing	Customizing my character	Escaping my daily life
First place (most fun)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Second place	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Third place	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Fourth place	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Fifth place	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Sixth place	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Seventh place	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Eighth place	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Nineth place	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Tenth place (least fun)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

10. **How much time do you spend sittingly on an average workday?**
Mark only one oval.

- ◯ Less than 2 hours per day
- ◯ 2 to 4 hours per day
- ◯ 4 to 6 hours per day
- ◯ 6 to 8 hours per day
- ◯ 8 to 10 hours per day
- ◯ 10 to 12 hours per day
- ◯ 12 to 14 hours per day
- ◯ More than 14 hours per day

11. **How much time do you spend sittingly on an average weekend day?**
Mark only one oval.

- ◯ Less than 2 hours per day
- ◯ 2 to 4 hours per day
- ◯ 4 to 6 hours per day
- ◯ 6 to 8 hours per day
- ◯ 8 to 10 hours per day
- ◯ 10 to 12 hours per day
- ◯ 12 to 14 hours per day
- ◯ More than 14 hours per day

12. **How much time do you have to spend sittingly on an average workday because of your work or study?**
Mark only one oval.

- ◯ Less than 2 hours per day
- ◯ 2 to 4 hours per day
- ◯ 4 to 6 hours per day
- ◯ 6 to 8 hours per day
- ◯ 8 to 10 hours per day
- ◯ More than 10 hours per day

13. **How much time do spend sittingly consecutively on an average workday?**
Mark only one oval.

- Less than 1 hour
- 1 to 2 hours
- 2 to 4 hours
- 4 to 6 hours
- 6 to 8 hours
- 8 to 10 hours
- 10 to 12 hours
- More than 12 hours

14. **How much time do spend sittingly consecutively on an average weekend day?**
Mark only one oval.

- Less than 1 hour
- 1 to 2 hours
- 2 to 4 hours
- 4 to 6 hours
- 6 to 8 hours
- 8 to 10 hours
- 10 to 12 hours
- More than 12 hours

15. **What do you think the effect of your sitting habit is on your health?**
Mark only one oval.

- Negative
- Negative but negligible
- No effect
- Positive but negligible
- Positive

16. **To what degree are you able to spend less time sittingly?**
Mark only one oval.

	1	2	3	4	5	
Totally not able						Totally able

17. **Do you use an activity tracker or app to register your physical activity?**
Mark only one oval.

- Yes
- No

18. **If so, what app or tracker do you use and how often do you use it?**

19. **Do you sport?**
Mark only one oval.

- Yes
- No

20. **If so, which sports and how often do you practice them?**

Questionnaire MOMG (Movement-Oriented Multiplayer Game) - Afterwards

*Required

1. **Name and surname**

2. **How many times per day on average did you play MOMG?**
   Mark only one oval.
   - Never
   - Once per day
   - Twice per day
   - 2 to 4 times per day
   - 4 to 6 times per day
   - More than 6 times per day

3. **Arrange the things listed below related to MOMG from most fun to least fun according to your personal preference.** *
   Mark only one oval per row.

	Unlock exclusive head and body sprites	Searching optimal ways to play	Taking the most steps per day	Completing competitive quests	Looking at the newsfeed	Talking to others about MOMG	Completing group quests	Discovering what others have built	Completing personal quests	Building things in the game world	Customizing my charachter	Escaping daily life
First place (most fun)												
Second place												
Third place												
Fourth place												
Fifth place												
Sixth place												
Seventh place												
Eighth place												
Ninth place												
Tenth place												
Eleventh place												
Twelfth place												

4. **How did you decide which quests you would complete and which not?**

5. **What would you think of MOMG if the game world had not been shared? Would this change improve the concept?**

6. **How much more did you walk due to playing MOMG?**

7. **How much more did you run due to playing MOMG?**

8. **How much less did you sit due to playing MOMG?**

9. **Did these changes mainly occur on workdays or on weekend days?**

10. **How much less did you sit consecutively due to playing MOMG?**

11. **What motivated you to play MOMG?**

12. **How long do you think the concept of MOMG (getting rewarded by being physically active) can be fun?**

Mark only one oval.

- I never thought it was fun
- A few days
- A few days to a week
- 1 to 2 weeks
- 2 to 4 weeks
- 1 to 3 months
- 3 to 6 months
- Longer than 6 months

13. **Did you use WiFi and/or 4G to play MOMG/upload your steps and how often did you use them?**

14. **How did you experience the daily mails (status reports)?**

15. **Rate this statement: the daily mails (status reports) motivated me to be more physically active.**
Mark only one oval.

	1	2	3	4	5	
Totally disagree	◯	◯	◯	◯	◯	Totally agree

16. **During the second half of the experiment you did not receive daily mails (status reports), would you rather have received them?**
Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Indifferent

17. **Rate this statement: I now (after participation) have a better idea of my daily physical activity than before participating.**
Mark only one oval.

	1	2	3	4	5	
Totally disagree	◯	◯	◯	◯	◯	Totally agree

18. **Aside from buying objects, would you have liked to be able to spend gold another way? Do you have any ideas yourself?**

19. **How many times did you view the newsfeed on average per day?**
Mark only one oval.

- ◯ Never
- ◯ Once per day
- ◯ Twice per day
- ◯ 2 to 4 times per day
- ◯ 4 to 6 times per day
- ◯ More than 6 times per day

20. **How did you experience the daily goals?**

21. **Would you rather have set the goal yourself or adjusted it?**
Mark only one oval.

- ◯ No, let the system set it for me.
- ◯ Yes, limited feedback: I would have liked to indicate what was achievable that day and what was not.
- ◯ Yes, I would have liked to set the goal myself.
- ◯ Other: _____

22. **Did you discuss MOMG with others? If so, with whom? (e.g. other players, friends, family)**

_____

_____

_____

_____

_____

23. **If you did discuss MOMG with others, what did you talk about?**

_____

_____

_____

_____

_____

24. **Did you get frustrated by something?**

_____

_____

_____

_____

_____

25. **Do you have any suggestions to improve this concept?**

_____

_____

_____

_____

_____

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