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A Serious Game to Treat Childhood Obesity

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Abstract—Serious games employ video game technology to convey serious content, facilitate learning, or initiate behavioral change. A common approach is to combine standard game mechanics with linear content expected to deliver the intended message. In contrast, we advocate an approach centered on player decisions and subjective experience, referring to innovative examples of learning by experience, both analog and digital. We present the design decisions underlying *Aquamorra*, a serious game to support the treatment of childhood obesity in the light of this approach.

I. INTRODUCTION

Our most recent project, *Aquamorra*, is a serious game to support the treatment of childhood obesity. We present *Aquamorra* in the light of our conviction that, in order to achieve high therapeutic efficacy, we need to look beyond conventional learning approaches, and focus on the unique properties of the employed medium, video games. There are a multitude of unique qualities to this medium, and as researchers striving for maturation of our discipline, it is of our utmost interest to identify, understand and expand upon these qualities. We begin with an introduction to recent approaches in childhood obesity therapy: Significant progress has been made in this area, and our goal is not to challenge prior work, but rather to promote synthesis with our own endeavors. We then address the state of the art in serious games for obesity, before discussing two key achievements in game design—both analog and digital—in the light of experimental learning theory. The bulk of this paper is then dedicated to discussing how *Aquamorra* contributes to our cause of creating a therapeutic experience true to the nature of the video-game medium.

II. CHILDHOOD OBESITY AND THERAPY

A. Prevalence and diagnostics

Worldwide, obesity has more than doubled since 1980; and childhood obesity in particular is one of the most serious public health challenges of the 21st century: no longer a high-income country problem, but on the rise in low- and middle-income countries, especially in urban environments [1]. Medical diagnosis draws a distinction between overweight and

obesity, defining a body mass index higher than 90 percentile referring to age group as overweight, a percentile higher than 97 as obesity, and a percentile higher than 99.5 as extreme obesity [2, p. 23]; according to the WHO growth reference for school-aged children and adolescents, one standard deviation body mass index for age and sex serves as threshold for overweight, and two standard deviations body mass index for age and sex for obesity. Such differing cut-off-points for defining overweight and obesity make a valid comparison of prevalence difficult. The prevalence in Germany is 10% to 18% in children and adolescents for overweight, 4% to 8% for obesity. Even higher results are reported for Austria, with roughly 20% of girls and 25% of boys overweight or obese, and 9% of boys and 6% percent of girls obese, with rapidly increasing prevalence rates. Global Health Observatory (GHO) data of the WHO reports the highest prevalence of overweight in the WHO Region of the Americas (61.3%) and lowest in South-East Asia (22.2%), with Europe close to the Americas (58.6%); prevalence of obesity following the same pattern of distribution (Americas: 26.8%, South-East Asia: 5%, and Europe: 23%) [1].

Obesity shows a high rate of co-morbidity with mental disorders including depression, anxiety disorder, psychosomatic and other eating disorders: these conditions showed significantly higher prevalence than in a control group [3], [4]. Childhood obesity results in serious consequences for somatic and mental health. Main somatic consequences are impairment of loco-motor system, cardiovascular diseases, hypertonia, diabetes, and decrease in life span expectancy. Risks for mental well-being include markedly reduced self-esteem, depression, as well as bulimia as additional eating disorder. Gender specific differences were found in self-esteem, significantly lower in obese girls than boys; estimation of body weight, with girls tending to overestimate their body weight and boys underestimating it but also showing higher impairment in acceptance by peers [4]. Risk factors for obesity in childhood and adolescence range from somatic parameters to changes in nutrition, but the emphasis lies on social, economic and emotional traits and conditions, such as maternal eating disorders, parental partnership problems, broken home families,

neglect in care-giving or other influences of education, trauma, and in particular a coincidence of sexual abuse and extreme obesity. Reported behavioral characteristics, such as lack of physical activity, may be taken as a symptom, but should not be mistaken as causal or etiological agents.

B. Psycho-dynamics and therapy

Over-eating is a seducing option for compensation or surrogate in various psycho-dynamic backgrounds. Eating can function as a substitute in many ways: swallowing aggression instead of acting out aggressive feelings, oral satisfaction instead of fulfillment of narcissistic desire, body mass defining self-defense borders instead of clear distinction. Physical inactivity can protect against body feeling and sexual attraction, if experienced as scary. Eating can help coping with frustration, reducing drive tension; it can provide quickly available pleasure and facilitate suppression of conflicts. The view on obesity as a syndrome caused by any out of a number of unconscious psycho-dynamic conflicts suggests that diets as the main or only therapeutic strategy are too narrow an approach and explains the related lack of success [5]. Efficient therapy is now seen to also require two additional pillars: Physical activity and change of eating habits, both requiring willingness to invest effort or even struggle; control of contradictory impulses; and frustration tolerance: all these are subsumed as conscious behavior control. The third pillar is modification of emotional state, which is not accessible to willful control, but shaped by unconscious emotional conditions.

Each of these three pillars calls for a particular, different approach: Physical activity and change of eating habits can be supported by learning processes and information provided by training and psycho-education, while the unfolding of obesity in its psycho-dynamic dimension requires psycho-therapeutic interventions. Following psycho-dynamic concepts of Individual Psychology, each mental health symptom is a manifestation that arises from unconscious emotional conflicts; at the same time, each symptom has a fictional final goal, determined by safeguarding tendencies [6]. Psychotherapy of obese children or adolescents therefore has to support the patients in their understanding the unconscious goal(s) of the symptom of over-eating and obesity, and to help create alternative and healthy problem-solving strategies. The psycho-dynamic dimension is crucial for efficacy of any supportive measures of training and psycho-education: Without this third pillar the other two remain unstable and run high risk to be discontinued. An obesity treatment program to reduce body weight is doomed to fail as long as the mental and emotional preconditions are not provided. On the other hand, starting an obesity treatment requires the insight of being obese or overweight, which poses heavy pressure on ego strength—a dimension of personality already likely to be fragile in obese children and adolescents. The first step in getting ready for a treatment program thus has to be to ascertain and strengthen the patient's ability of self-reflection. This again underscores the need of early psycho-therapeutic support to even enter a treatment program, since awareness of being obese can result in a high

risk of loss of self-esteem. Furthermore, discontinuation of treatment increases the risk of obtaining an even higher level of obesity, as long as handling of frustration is linked to eating. Psychotherapy of children and adolescents, and this goes for any symptom of mental disorder, always requires cooperation with parents and care-givers to be successful [7]. A consensual statement based on efficacy studies confirms this also to hold for treatment of obesity [2].

III. STATE OF THE ART IN SERIOUS GAMES FOR OBESITY

Serious games designed and developed specifically to support therapeutic treatment of obesity are rare. Even so, there is one prominent example we want to address here, as it follows a strategy that is, to some extent, in vein with our own approach and yet very different: the Playmancer project [8], [9], aimed at developing and assessing a serious video game to assist in the treatment of underlying processes in eating and impulse control disorders, such as a lack of self-control strategies. We agree that in order to facilitate long-term change it is essential to address underlying processes such as impulse control, affect regulation, self-esteem, and problem solving strategies. For the Playmancer project, this approach was indicated since the project was not specifically developed to support the treatment of obesity, but for the treatment of various mental disorders related to impaired impulse control. "Islands", the game scenario of Playmancer [8], places the player on a virtual archipelago: Each island features different challenges and situations linked to different skills and attitudes to be improved or changed. The game employs bio-sensors and emotion-detection feature-extraction algorithms to infer the user's affective state. The game automatically reacts to the player's emotional state by co-varying the difficulty level with the player's arousal (the calmer the player, the easier the game): A smart way to combine video game technology with bio-feedback to create meaningful feedback loops. At the same time, there is little innovation in regard to game design itself: For example, in a scenario called "The Face of Cronos", the player has to plan a climbing path up a cliff while managing their resources and avoiding obstacles. In "Treasure of the Sea", the player swims underwater, gathering artifacts and balloon fish while managing and maintaining their oxygen level. Finally, "Sign of the Magupta" is a relaxation game involving the drawing of star constellations. Clearly, the Playmancer project placed an emphasis on emotion detection technologies and adaptive gameplay rather than on game design itself. The issue we see here is that if gameplay fails to immerse the player into the gaming experience, the mentioned technologies will likely fail to live up to their potential. We thus do argue that to achieve high efficacy in therapy and learning, the player has to reach the often-advocated state of flow [10]. Related to that, there has been a bulk of research on *Ludemes* [11], gameplay elements contributing to this experience. According to Ralph Koster [12], most successful games are made up of the following elements:

- Preparation
- A sense of space

TABLE I
SCHEME OF *Aquamorra* GAME MECHANICS, WITH DESIGNATED EFFECT OR IMPACT

Game mechanics	Designated effect or impact
Oxygen bubbles	Impulse control & food literacy
Mood display	Impulse control
Cross-media action cards	Involving caretakers & first-level experience
Level advancement and in-game reputation and reward	Increased learning through emotional attachment

- A solid core mechanics
- A range of challenges
- A range of abilities required to solve the encounter
- Skill required in using the ability
- A variable feedback system
- The mastery problem must be dealt with
- Failure must have a cost

While Koster’s work does not address all the particularities of serious games in therapy, this list provided precious input to our own approach. In the next section, we will take a step beyond immersive gameplay and discuss game mechanics can be used to reinforce the message to be delivered.

IV. EXPERIENTIAL LEARNING IN A VIRTUAL WORLD

The mechanics is the message, a slogan coined by veteran game designer Brenda Romero [13], may serve as mantra for game developers striving to create game experiences promoting deeper understanding. Romeros award-winning and critically-acclaimed analog works can be highly inspirational for every video-game designer interested in advancing the maturity of the medium. Romeros work discussed here is not about digital games per se, but about analog installations presented at exhibitions and museums. Yet, much can be learned from the concepts they entail. Take for example the project “Train”, exhibited in the Museum of Design in Atlanta in 2013: In this game, the player is asked to read simple typewritten instructions. The playboard is composed of a series of train tracks and some wagons. The playing pieces consist of small yellow tokens, as for example seen in Ludo or other games. The player’s task is to distribute these tokens as efficiently as possible across the wagons. One play-through takes between two minutes and two hours, depending on when the player makes a significant discovery. During the game, the player has to pick randomly shuffled action cards from a staple that specify different tasks and instructions. One of these cards finally reveals the destination of the wagons: “Auschwitz”. This moment is intended to trigger a strong emotional reaction in the player, as the positive feeling of mastering and winning the game all of a sudden topples over into a extremely negative feeling of just having spent up to two hours trying to efficiently transport prisoners into a concentration death camp. The main emotion the user is expected to experience and understand is that of *complicity*.

When thinking of a digital game that is similarly successful in making the player understand what it means to “be in someone else’s place”, the game “Paper Please” [14] comes to

mind. In this game, the player takes on the role of a nameless citizen of the totalitarian fictional State of Arstotzka, who gets assigned by the state the responsibility for border control. It is then up to the player to make countless decisions every day, whether or not immigrants are allowed to cross the border. This is made especially challenging due to the fact that Arstotzkas entry regulations change on a daily basis. Additionally, there are a mysterious EZIC society as well as the national secret service, who constantly try to influence the player’s decisions in their favor. The tasks of the player are extremely repetitive: Check visa, comparing them with a rule book, and grant or deny entry. The consequences of wrong decisions are severe, forcing the player to stay focused and alert. Through their experience, players should understand what it means to be that immigration officer.

If we reflect on these approaches in the light of some of the core propositions of experimental learning theory as presented in [15, p. 43], there is a strong point for focusing more on mechanics than narrative to convey a stronger message—always with due concern for the required ethical scaffolding. The first proposition made is to *best conceive of learning as a process rather than in terms of outcomes*. To improve learning, the authors explain, the primary focus should be on engaging in a process that includes feedback on the effectiveness of their learning efforts. This can be taken as strong argument to develop video games for educational purposes, since video games are especially suitable for delivering immediate feedback to user interactions. Many researchers, especially if familiar with the concept of gamification, may be inclined to think in terms of points, badges, and leaderboards; but this is not what this is about (for an excellent introduction to this topic see [16]). What we advocate is the feedback received by immersive interaction and subjectively meaningful consequences to users’ actions. “*All learning is re-learning*”, the second proposition, is about challenging the learners’ beliefs and ideas and putting them in new perspective: Another inherent strength of virtual worlds, which allow to alter the scenario to remain in line with the lessons to be learned. Especially for developers of serious games in psychotherapy [17], [18] this is a familiar approach, since psycho-therapeutic approaches often focus on making the client aware of erroneous patterns of thinking and helping them to find better alternatives [19], [20], [21]. A last proposition is that *learning is a holistic process of adaptation* [15], i.e., not just the result of cognition, but involves the integrated functioning of the whole person—thinking, feeling,

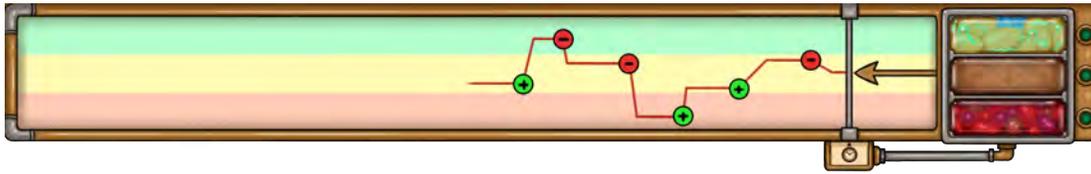


Fig. 1. Progression of Mood Level in *Aquamorra*.

perceiving, and behaving: yet another argument why learning within an interactive medium such as video games *may* be more powerful than linear media such as books or movies, *if* use of new media goes beyond trying to integrate traditional media (e.g., cut-scenes and the like) into a gaming framework.

V. *Aquamorra* — THE OBESITY TREATMENT GAME

A. *Aquamorra* Gameplay

In *Aquamorra*, the player assumes the role of a young human-like character of either gender, who crash-landed their spaceship on a strange liquid planet inhabited by three competing families, the Aquamorra. At first, the player finds themselves adrift in an escape capsule, but soon discovers out that they possess a special power allowing them to manipulate the environment in their own favor. By strategically utilizing these powers, they is soon able to maneuver the capsule through this underwater labyrinth in order to reconnect with their spaceship, which is also a fully functional submarine. The ship is small at first, and relatively powerless, but soon the player learns of merchants willing to sell upgrades for the right price. While trade as such is secondary to the game’s overall message, the upgrades the player is able to purchase constitute a precious increase to the player’s authority, agency and capabilities in the game world. This premise is simple yet intriguing and, together with captivating visuals and usability, provides the scaffolding for the core mechanics intended to precipitate change. The player character has two attributes of pervasive influence on all gameplay elements.

The first is “*mood*” (Figure 1). If the player character’s mood level is high, they can choose between three modes of interaction with the world and other characters: *open*, *protective*, and *aggressive*. If the mood level is low, *aggressive* mode is the only available option. Each mode has not only direct influence on available interactions, but also significantly alters the appearance of the player and their ship (Figure 2). The second is the “*friendship value*”, which is similar to a reputation system among non-player characters in the game world. The friendship level is different for each of the three families in the game world and changes according to the players interactions with members of each family.

The game uses the Unity Game Engine and hand-drawn 2D art and animations to bring *Aquamorras* unique underwater world to life (Figure 3). The game is designed for mobile platforms (currently, iOS and Android tablets) and features intuitive touch controls for direct interactions, with the single players ship and the game world itself. The gameplay is



Fig. 2. Skin Types for the player’s ship

physics-based: oxygen is the main physical force, generating the ship’s thrust or moving it through external effects, including vents and the bursting of bubbles in proximity of the ship; at the same time, bubbles can also turn into unsurmountable obstructors. The ship is steered by directly touching its turbines, causing air to be released and propelling the ship. The resulting decrease of the ship’s overall oxygen supplies has to be addressed by refilling the tanks with oxygen bubbles floating in the game world.

Oxygen thus is the main resource in the game world, collectible from three different types of floating bubbles: green, yellow, and red. These bubbles represent three different categories of food, as explicated through the display of representatives of each group whenever they are picked up. To reinforce the understanding of the connection between bubble types and food categories, bubbles categories differ in the amounts of oxygen (“calories”) provided as well as in their impact on the mood of the player character: green bubbles provide the smallest amounts of oxygen and affect the mood level positively; yellow bubbles are richer in oxygen and do not alter the mood; red bubbles provide the highest oxygen



Fig. 3. The World of *Aquamorra* (German localisation: “Zurück” = “Back”).

supplies, but also have negative long-term effects on the player character’s mood. The necessary nourishment provided in the form of oxygen bubbles is but one influence on the player character’s mood level: The lesson to be learned is that while eating *can* be used as a short-term mood regulation device (i.e., “binge eating makes you happy”), its long-term effects are negative (e.g., “you feel guilty after stuffing yourself with fast food”). Solving quests in the game world is a different available option to increase the mood level: The lesson to be learned is that being productive and self-sufficient can have longer-lasting and more pervasive positive impact on your mood. Finally, and most importantly, there is the *social component* of the game: Positive interaction with non-player characters has a strong positive effect on the mood level, while negative (i.e., hostile) interaction has a marked negative effect. This is strengthened through the “friendship level”, meant to confer the lesson that positive interaction with peers increases one’s mood and has positive impact on one’s social status. Table I provides a quick overview of our game mechanics and the designated effect or impact.

Game mechanics of therapeutic value however do not suffice to guarantee successful therapy integration: We also have to live up to children’s high expectations of modern video games. To this end, children participated in the iterative development at all stages of the project, from early concept arts and character creation to final game play, and we therefore are confident to have created an experience that motivates children to actively “come back for more”, a key requirement for the *cross-media component* covered in the next section.

B. *Aquamorra* Therapy Integration

As stated earlier, *Aquamorra* is *not* intended to be a self-help tool to replace regular therapy, but rather an adjuvant that ties seamlessly into standard obesity intervention. We do not claim that the transfer of learning from the virtual world to real life scenarios is strong enough to guarantee efficacy in a therapeutic sense. Yet, if applied by a trained therapist who reinforces and expands upon the games concepts, we do believe that the game leads to valuable effects. To deepen the cross-media approach and tie the game stronger to the patients’ daily lives, the game ships with a number of *physical tasks cards* (Figure 4), which can be redeemed with the game-world merchants. These cards depict a number of tasks, ranging from sport activities, over food-related activities, to social interactions. During a first introductory session, the parents or caretakers of the child client will select a number of cards jointly with the therapist that appear most indicated for the clients therapeutic process. This is meant to allow tailoring the serious-game experience and therapeutic process to the client’s individual needs, and at the same time involves the parents/caretakers into the therapeutic process, yet another aspect of utmost importance.

VI. CONCLUSION AND OUTLOOK

Aquamorra is one of the first games specifically designed to support the treatment of childhood obesity. In this paper, we have introduced our approach that focuses on understanding through first-hand experience. *Aquamorra* does not rely on classic narrative to deliver the intended message, but rather embodies the message in the game’s core mechanics. Through this approach, we hope to not only further the application of



Fig. 4. A Task Card

serious games in health care and therapy, but also to contribute to the growth of the medium, according to its very nature.

At the time of writing, *Aquamorra* is undergoing extensive playtesting and debugging: first clinical evaluation results should be available in spring 2016.

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