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A European Serious Gaming 3D Environment

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1 Introduction

PlayMancer games are serious games that are intended to be used as a supplement to regular treatment for mental disorders such as binge eating and for chronic pain rehabilitation. PlayMancer, while playable by anyone, is not addressing the mass video game market.

This document describes the game design decisions for both of the two PlayMancer games, targeting mental disorders patients and pain rehabilitation patients respectively. As it is explained in the second chapter, each game is sharing a common world, but consists of three different mini-games. Each of the mini-games is designed to cater for specific user requirements coming from the project experts in the 2 different domains, IDIBELL (for mental disorders) and RRD (for pain rehabilitation).

Chapters 3 and 4 are describing the game parts that are shared between the 2 games, the starting point of the ship, and the exploration part of the island.

Chapters 5 to 10 are presenting the game play design of the 6 mini-games that the 2 games include. Specifically, chapters 5, 7, 9 correspond to the 3 mini-games that belong to the RRD game for pain rehabilitation, while chapters 6, 8 and 10 cover the 3 mini-games that belong to the IDIBELL game for mental disorders.

Finally, chapter 11 presents the current stage of implementation regarding the project plan and refer to the tasks and activities that follow the development of the final game prototypes.

2 Common universe, different games for PlayMancer end-users

PlayMancer has produced 2 different games, each targeting a different user audience, a different application domain. One is intended to be played by mental disorder patients (eg. suffering from binge eating syndrome), the other is made to address pain rehabilitation patients. Experts from partners IDIBELL (for mental-related disorders) and RRD (for pain rehabilitation) have provided with adequate user requirements in deliverables 2.1 and 2.4.

The two produced PlayMancer games share the same storyline, and some of the assets that make up the games. They differ in the design and use of the mini-games that are included in these two games, each one of which is carefully designed and implemented for the target group that the whole game is aiming at. A single story line for both applications was chosen to reduce the development time. This provided an overall structure, while the mini games focused on addressing the specific therapeutic requirements.

2.1 The storyline: The Rise and Fall of the Magupta

For centuries *The Island of Mighty Cronos* was only hinted at in myths. The island, which was thought to have given rise to a marvellous tribe of engineers, the Magupta, was said to have been sunk in one of the dreaded *Millennia Storms* that appears once every 1000 years, eliminating the entire civilization.

Recently, what seems to be a yet un-charted island has appeared in the Mediterranean. Could this be the mysterious Island of Cronos?

The mere thought of discovery has lured many adventurers and explorers to this new island. The player, being one of these explorers, arrive by ship and anchors in the

bay. Having the ship as a base, the player ventures the inland to discover the marvels of the lost Magupta civilization.

- The civilization of engineers. Inspired by Mayan / Aztec civilizations.
- The Island of Cronos. Inspired by the Atlantis myth and the Bermuda triangle.
- The player. The player takes on the tasks of an explorer / adventurer / archaeologist.

The main game setting was chosen to be an island. Islands are easily associated with adventure, vacation, fun and relaxation. For the more adventurous, there are associations with getting lost, finding hidden treasures. For the hedonist, it is all about vacation and relaxation. Having a setting that is removed from the daily problems of potential users is also important. The island setting also lends itself to expansion to many islands, which, in fact was the first idea for the game setting.

A tropical island is a pleasant, calm setting, and a place you want to visit (warm and sunny, nature, peaceful). The main location was also chosen and designed graphically in order to be visually pleasing and calming. Patients may not be regular gamers and in this case they will not be as reluctant to enter the game world if it appears pleasing and welcoming. Considering it is the player's choice (as mentioned in the introduction narrative) to sail to the island, the feeling of exploration and it being your island greatly overshadows any feelings of solitude (alone on the island) – the underlying message is that the player is not a marooned victim, but an empowered explorer¹.

¹ When considering the attitudinal and personality features of the end users (characterized by impulsiveness, exploratory excitability, novelty seeking, adventure seekers), together with their age, it was decided together with clinicians that such a scenario might be the optimal one. These decisions were supported by the findings from the first pilot trial study (bridge-building) of the mental health game where the end users showed good attitude for this type of scenario, but also adequate level of excitability (data presented at the Boston-2010 [8] and Las Vegas-2010 [9], conferences).

Unlike virtual reality, or therapeutic support for phobias or anxiety, where the therapeutic setting might be progressive exposure to heights, open spaces, or spiders (or other phobias), the therapeutic setting for complex behavioural disorders should target underlying behaviour, and not a stereotypical setting.

The mythological setting reinforces the move away from the daily setting (Binging) or stereotypical activities for a particular group or population (old people at a café or tea room, etc.). The storyline and narrative framing (the Magupta empire, island that resurfaces, mythological story) was inspired by the Bermuda / Atlantis stories/myths, and the Aztec / Mayan cultures, in order to give room for imagination and exploration, but also a degree of recognition for the patient/player. A realistic setting with fantasy/mythological elements draws on a huge narrative corpus (Indiana Jones, Harry Potter, fairy tales, Brothers Grimm, Hans Christian Andersen, Lord of the Rings) and has thus always had a great appeal to a broad target audience. Making a game for such a versatile group, as was the case with the RRD and Idibell patients (versatile even within each patient group), would require a setting and a narrative that would appeal broadly.

2.2 Game world and navigation

There are two primary locations in each of the games: The Ship and The Island. The ship is the player's base, and the island is where the exploration and mini-games take place. The following explains the basic functionality of each of these two locations.

Location 1 - The Ship: This is the home of the player. While on the ship, the player may view her progress in the game or calibrate the input devices that assist in the Playmancer serious games, or have a look at the player's profile.

Location 2 - The Island: The island is a 3D environment where the avatar can walk around, exploring the tranquil tropical setting, and access the mini-games from specific locations on the island.

2.3 The mini-games

Rise and Fall of the Magupta comprises of 6 mini games:

1. The Temple of Magupta
2. Treasures of the Sea
3. The Three Wind Gods
4. The Face of Cronos (mental health version)
5. The Face of Cronos (pain rehabilitation version)
6. Sign of the Magupta

The actual content and game play of each of the mini-games was then decided on in co-operation with partners RRD and Idibell respectively. Each mini-game addresses one or more aspects of the therapeutic goals of the project (please see deliverable D2.4 Tables 2 and 3).

The affection-based game intended to serve the mental health group of users, is configured to use the second, fourth and sixth ones:

- Treasures of the Sea:
 - Reward planning
 - Help avoid impulsivity over planning
 - Experience relaxation as a success parameter
- The Face of Cronos:
 - Reward strategic planning
 - Help avoid impulsivity over planning
 - Experience relaxation as a success parameter
- Sign of the Magupta (Star Gazing):
 - Tool which allows the player to relax
 - An exercise the player can recall later

The motion capture-based game intended to serve the chronic pain rehabilitation group of users, is configured to use the first, third and fifth ones.

- The Temple of Magupta:
 - Increase walking speed
 - Improve constitution
- The Three Wind Gods:
 - Increase ROM (range of motion)
 - Increase motion velocity and smoothness
- The Face of Cronos:
 - Improve reaching ability
 - Increase motion velocity and smoothness

Input configurations are different for each game. The final game playing experience is consistent for each user group, since the same input devices and methods are used for all related mini games. Emotions of mental health patients are recognised through face expressions, speech, and bio-signal devices and used to assess each mini-game progress in the affection-based game. Furthermore, direct input from respiration and heart rate sensors are used in the Sign of Magupta mini-game. Motion capture and speech are used to update the mini-game states in the motion-capture-based game. These different configurations are summarised in the following table (ER stands for emotion recognition):

Table 1: Input controls for Playmancer mini-games

Game	Mini-Game	Keyboard/ Mouse	ER /speech	ER /bio-signals	ER /facial expressions	Respiration/HR	Motion Capture	Speech ASR	EMG
Pain rehabilitation	The Temple of Magupta						✓	✓	

Mental health	Treasures of the Sea	√	√	√	√				
Pain rehabilitation	The Three Wind Gods						√		
Mental health	The Face of Cronos (mental health version)	√	√	√	√				
Pain rehabilitation	The Face of Cronos (pain rehabilitation version)						√	√	√
Mental health	Sign of the Magupta		√	√	√	√			

For some of the pain rehabilitation exercises (e.g. Temple of Magupta and Face of Cronos), the player might not be able to see the game while they are moving their body. In these cases voice commands or other audio input or output gives some flexibility. In the pain rehabilitation games the player controls the avatar using his/her body-motions and voice. The body-motions are related to the physical exercises that the patient needs to do during the mini-games. The speech control of the avatar was needed, since the patient, wearing a motion-capture suit and standing on a treadmill, would not be able to sufficiently operate a keyboard or mouse (to control the avatar) while exercising. Other control devices would, to a much larger extent than speech, interfere with the training. This is why we have implemented Speech ASR as a user input interface in the pain rehabilitation PlayMancer game.

2.4 Game flow for the mental health game

The flow of the game goes through the same structural steps every time the patient plays. These are:

1. Introductory relaxation sequence: a sequence of slow-motion cinematic animation of an island scene, with relaxing “heart-beating” visual and sound effects. The main purpose of the “relaxation sequence” at the beginning is mainly for calibrating the baseline of the different sensors. Otherwise, learning to be calm and relax is done in the games themselves, through the breathing exercises, and remaining calm during the diving or the climbing games.
2. Ship: Calibrating, status on progress (in-game achievements), deciding which mini-games/tasks to try.
3. Island: The player travels to the island where in specific locations she can initiate mini-game(s). This could either be one or several repetitions. When the task is complete, or the player decides to end it, she is transported back to the ship, or back to the island.
4. Mini-game world: After a mini-game is started, the player is transferred in the mini-game 3D world, much like the 3D island scene at the triggering location. Then, the player or the practitioner may decide to end the mini-game at any point and return to the island. When a mini-game is finished (successfully or unsuccessfully) the player may start again, or exit back to the island, or be transported back to the ship.
5. Ship: The player is rewarded (if the task was successful or the effort was sufficient to merit a reward). The player can now choose to either do another task or end the game.

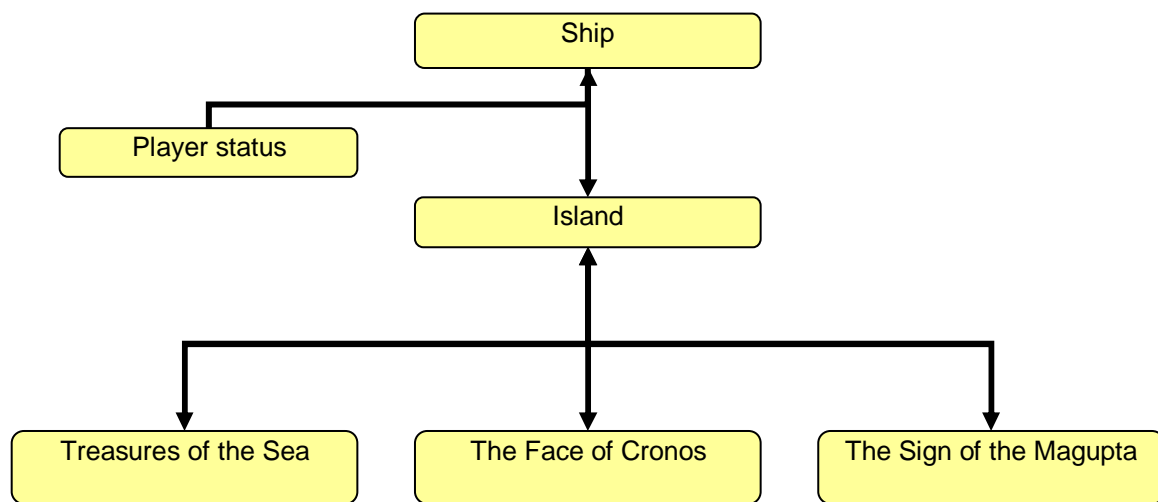
All three mini-games are suitable for the mental disorder patients, each addressing specific aspect(s) of the CBT (Cognitive-Behavioural Therapy):

- Stress and frustration management, emotional awareness: Treasures of the Sea (diving in sea)
- Stress and frustration management, coping and planning skills: The Face of Cronos (climbing a cliff)
- Improve relaxation, master calmness: Sign of the Magupta (star gazing)

In real life, rock climbing and diving are both exercises that demand focus and calmness from the person performing them. Anger, lack of focus (i.e. boredom), becoming excited, or similar responses, according to deliverable 2.4 (version June 2010) are behaviours that the patients need to control.

Stargazing and trying to spot constellations on the night sky, is a relaxing exercise that most people can relate to. It's a tranquil situation that is easy to recall.

The following chart presents the game states and possible transitions.



The mini-games have levels of difficulty. Generally, while there is a scripted-mapping between mini-game levels and rewards, this is not critical for the success of the game. For future exploitation purposes, the mapping of challenge levels, progression and rewards might have to be more prominently displayed and better explained. Nonetheless, it should be reemphasized that repetition, and getting the participants to do the exercises is the main goal, which is primarily encouraged by the therapist and secondary by the game rewards.

2.4.1 Expected and unexpected user reaction, benefits and risks in the designed game flow

Specifically, PlayMancer's Islands serious game, addressed to some mental health disorders, consists of a videogame of adventure in which the player confronts distinct challenges and situations in order to improve the skills and attitudes that we are trying to change (i.e. problem solving, impulse control, confronting situations associated to frustration and adverse emotion management). As the player completes the various tasks of the game, she can advance to higher levels of difficulty. The serious objective of the game is the patient/player to achieve a greater capacity of self-control. At all times, the patient will receive feedback regarding his or hers achievements.

The game consists of specifically designed series of tasks, which the patient should carry out in order to advance in his or hers self-development. As written in D2.1c Game Scenarios the game tasks to be carried out is a variation of the following major four ones:

- Exploring
- Diving
- Climbing
- Star gazing

Evaluation trials with patients will start after this point that the game prototypes are ready. The patients during the evaluation trials, will experience a cycle of game-playing combined with traditional CBT therapy. For 16 sessions through out a period of 4 months (once a week) the patients will individually play the mental health game and have a session with a psychiatric specialist, following a prospective longitudinal cohort study (program group and comparison group). The game will be applied after each individual session, once a week, during 45-50 minutes, in a dedicated space.

During each game session, raw data and emotion recognition data will be gathered in order to be manually processed. Some of the underlying processes and features that characterise the objects of the study, are the following:

Urgency:	Pressing importance requiring speedy action
Lack of premeditation:	Lack of planning or plotting in advance of acting
Lack of perseverance:	Lack of persisting, continuing or repeating behaviours or specific goals.
Sensation seeking:	The process in which the individual actively seeks out stimulation from the environment.

Some unexpected player reactions using the Video game could be over-expression of emotion with consequent over physiological reactivity (i.e. high anxiety with over expressed sympathetic symptoms and inadequate expression of emotions, hot-anger). Due to the controlled inclusion and exclusion criteria and sample selection, it is not likely that these sort of emotions will occur. We have excluded (as stated in D2.4) Patients with impulsive-explosive and antisocial personality disorder, or other psychiatric problems and all the cases, before engaged in this study will be screened and face-to-face interviewed by experienced clinical psychologist and/or psychiatrists).

The tests will be conducted under experimental conditions, in a safe environment-hospital and with continuous supervision by therapist in a close room. Due to that controlled condition of our treatment and test and due to close monitoring and supervision of the patients by the psychologist in each session, if the patient starts to get worse and experience side effects, he/she will be excluded from the study and will continue a standard treatment only. As reported at the inform consent, the patient is able at anytime to quit the test and to abandon the study.

During the entire test, the participants will be doing a parallel CBT therapy, in which the psychologist will control any potential side effects.

During implementation of the games, a set of pilot trials have been conducted, each belonging to a different iteration of the evolutionary prototype refinement process:

- Pilot trial 1: initial data acquisition, annotation and analysis of interaction between biosensors and emotions in front of different types of commercial videogames, with healthy controls balanced by sex
- Pilot trial 2: testing an intermediate (now obsolete) prototype called “Bridge-building”, analysis of physiological reactivity, and attitudinal reactions of users (conducted in pathological gamblers, eating disorders and healthy controls)
- Pilot trial 3: testing the final game prototype with new biosensors, analysis of the reactions in front of the new game and device with a small sample of healthy subjects
- Pilot trail 4: Final trial with patient control groups (with and without the PlayMancer serious game treatment)

Some of the early game prototypes, i.e. the bridge building game, were considered and rejected. The last versions of the mini-games were improved continuously, up to the clinical evaluations.

An anticipated risk in affective computer games such as the mental health PlayMancer game is the possibility of the player to experience affective states triggered by emotion recognition and resulted from bad game design. In the case that the patient fails to progress in the game, negative emotions (e.g. anger) might be experienced attributed to that fact and not to the personality traits of the patient, which once they are recognised by the emotion recognition components will trigger the affective-based game feedback mechanisms.

Considering the personality traits of our patients, and the clarifying rational and purpose of Islands explained to them before starting the videogame therapy, the main goal with behavioural and mental disorders is to get self-control. For the patients, being able to increase these lacking skills was acting as crucial motivating factor itself. Afterwards, this consideration was supported by the feedback of patients who successfully used the videogame, who expressed that one of the most relevant motivating factors for encouraging the continuation of the therapy were some external game factors (their own improvements while reacting more calmed down in

front of new life events and the positive reinforcement of the family) and internal game factors (the expectation to be able to have higher self-control and relax faster than in the previous session). This observation, along the player advancement mechanism explained in section 3, supports the ability of the game design not to demotivate the patient when they do not progress in the game as fast and as far as they might wish.

Another similar risk, is the player entering a vicious circle of frustration, by reaching a “death spiral” in the game (frustration leading to failure, leading to more frustration, till the user quits the game). There are several steps that will help avoid this issue, which the PlayMancer game for mental health followed:

- First, the games should be designed NOT to be too difficult to prevent users from advancing,
- The fine tuning between the level of difficulty and frustration versus planning skills required to get the maximum benefits is an ongoing process and requires many careful iterations. It is recommended that a game should define one (or just a few) overall difficulty parameter, simple and meaningful to the therapist, that can be easily adjusted during iterations.
- Finally, it should not be forgotten that the game is played inside a therapeutic environment. The player is not alone. When the patients are experiencing frustration, it is recommended that the therapist discuss and explore the issue with the patient during the sessions. One of the main reasons for having the therapist in the experimental room is to avoid the hypothetical vicious circle of frustration. In our trials with patients, from the beginning, the patients were advised to use the relaxation section of the island (Sign of Magupta mini-game) in the hypothetical case that they would not find a way to reduce frustration and to stay calm down. None of the patients explored had the need to abruptly interrupt the game session due to excessive feelings of frustration. The presence of the therapist and the hospital scenario may have a double positive effect, by giving them an additional feeling of security.

In terms of game difficulty, the fine tuning between the level of difficulty and frustration versus planning skills required to get the maximum benefits is an ongoing process and requires many careful iterations. It is recommended that a game should define one (or just a few) overall difficulty parameter, simple and meaningful to the therapist, that can be easily adjusted during iterations. In the PlayMancer mental health game, increasing the difficulty was easy to adjust in this version.

Both the climbing game and the diving game will propose to the player, that s/he plays the relaxation game, if the player gets too bored or angry. For both the climbing and the diving game, this also works as a visualization of the player's current state, thus visualizing for the player how he/she feels. This can be helpful for the player in order to "get in touch" with his/her own emotions and better understand the potential danger signals.

Increased boredom / anger can be seen as punishing the player – and it is, in relation to the game play – but what the player has to learn and must do to overcome it, is to calm him-/herself before proceeding with the game. The game gets harder, but only if the player does not stop and think or plan a new course. This is an important learning point for the patient.

2.5 Game flow for the chronic pain rehabilitation game

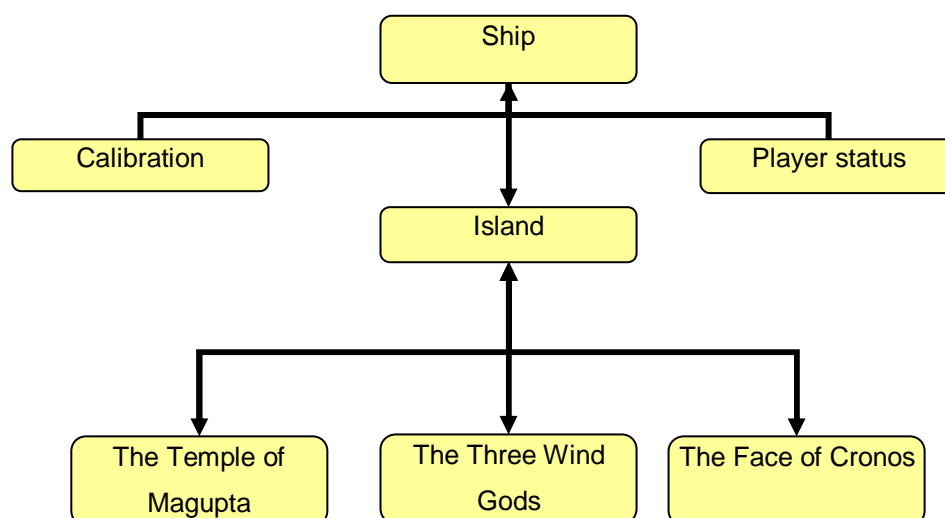
Similarly with the mental health game, the flow of the chronic pain rehabilitation game goes through the following structural steps, allowing a degree of freedom from the player's side to choose the steps that will be explored at any given time:

1. Ship: Calibrating, status on progress (in-game achievements), deciding which task(s) to do.
2. Island: The player can be transferred to specific island locations and start the respective mini-games by using the in-game island map. At given places/positions, there are cues leading to each of the mini-games, via a step-in triggering mechanism.
3. Mini-game world: After a mini-game is started, the player is transferred in the mini-game 3D world, much like the 3D island scene at the triggering location. Then, the player or the practitioner may decide to end the mini-game at any point and return the island. When a mini-game is finished (successfully or unsuccessfully) the player may start again, or exit back to the island, or be transported back to the ship.

4. Ship: The player is rewarded (if the task was successful or the effort was sufficient to merit a reward). The player can now choose to either do another task or end the game.

The following describes the three mini-games for the chronic pain patients. The mini-games will not be linked, in order to allow for various combinations and repetition of exercises. The correspondence between exercises and mini-games is shown below:

- Walking on treadmill: *The Temple of Magupta*
- Cervical ROM: *The Three Wind-Gods*
- Reaching: *The Face of Cronos*



As with the mental health game, the mini-games of the pain rehabilitation game have levels of difficulty. Generally, while there is a scripted- mapping between mini-game levels and rewards, this is not critical for the success of the game. For future exploitation purposes, the mapping of challenge levels, progression and rewards might have to be more prominently displayed and better explained. Nonetheless, it should be reemphasized that repetition, and getting the participants to do the exercises is the main goal, which is primarily encouraged by the therapist and secondary by the game rewards.

2.5.1 Expected and unexpected user reaction, benefits and risks in the designed game flow

The ultimate aim is to reduce the amount of pain-related disabilities that a patient experiences in his every day life.

The game environment (the game and the multimodal input modules) are continuously interpreting the patient input. The accuracy of this interpretation is crucial for the successful application of the game in the rehabilitation therapy program. That is why the rehabilitation game has included thorough calibration stages. First of all, before the actual game starts, the player should calibrate the motion capture module by iterating a given procedure. This calibration is performed before starting any of the mini-games. If no changes on the input-side have occurred (e.g. change of marker-placement on the MoCap-suit) the calibration of a previous therapy/game-session(of the same patient) can be used. If for any reason the therapist observes that the system does not correctly or accurately interprets patient's motion as mapped to avatar performance (animation/scoring), then the mini-game should be stopped and the calibration should be repeated.

In the case where the player finds a mini-game too difficult or too challenging, the therapist may lower the difficulty level of that mini-game. The level of difficulty of the 3 mini-games that implement different exercises can be manually calibrated. The therapist and patient can adjust the calibrated numbers manually, which allows them to increase or decrease difficulty / the scope of the exercises as they see fit.

An additional risk for the Temple of Magupta mini-game, where a treadmill is used, is the patient to lose balance and fall off the treadmill. This is anticipated by the speech-based interface for changing left or right lanes, which is unobtrusive and allows the patient to grasp the treadmill handles during the exercise when she feels losing her balance, minimising the falling risk. Patients with severe limitations will not participate in the study, while for smaller limitations we have the baseline-calibration which tailors the goals of the exercise to the patient's ROM.

3 The ship

The ship is the home of the player. This is where she calibrates before venturing inland. This is also where her achievements (i.e. patient progress) are stored, either in the form of Artifacts (graphical) or Tablets (narrative).

Through the graphical UI of the ship location, three different objectives of the serious game are served:

- Graphical indication of the player's progress in the game world
- Accessing the player's profile and mini-games results, used for tracing the player's therapeutic progress
- Interactive game calibration of the connected input devices, so that their readings during the mini-games execution is as accurate as possible
 - For the pain-rehabilitation we also set the individualized baselines and goals for the mini-games as described below

The progress of the player is measured by two factors: the number of artifacts found in the mini-games that the player has played, and the number of tablets that have been unlocked so far. At the ship the number of artifacts that the player has found during the mini-games will be shown. Also, the nine tablets that contain the narrative reward of the game are shown here from the start. Each of the tablets can be unlocked (visible to the player) or locked (their faces will be empty). These will be unlocked as the player progresses in the game. That way the player will ultimately have unlocked all nine tablets at the end of the therapy sessions.

The first tablet is unlocked when 10 points worth of artifacts have been gained, the next needs 100 points, then 500, and for the remaining six tablets 1000 points are needed for each. The progress line towards unlocking a tablet is shown with a horizontal line. There are a total of nine tablets, comprising the entire history of the empire.

Since the unlocking of tablets is based solely on the player's score, the actual therapeutic achievements, that the patient might have accomplished, have no effect on neither the amount of points a player gets or the unlocking of the narrative (apart from a player getting more points when being more accomplished in the game, either due to therapeutic improvements or game play experience). This way, a patient that didn't improve much during sessions would not be penalized if she at least still tried to reach the goals of her therapy/rehabilitation. The goal of this mechanism is to reward success and not to penalise or punish effort. More on the player advancement scheme can be found in page 12 of project deliverable D5.4.

We have to stress here that the emphasis of the game is on repetition and not so much on the progress made through the game. That is why the rewards are narrative rewards rather than points, or more time underwater rather than more points. Also, an important distinction of the Playmancer games is that both are designed to be played as part of the clinical session. The therapist will be present nearby the patient, for guidance and debriefing. Typical games are not played in this setting. These design principles applied in the two PlayMancer games are tackling the issue of player de-satisfaction from game failures or inability to progress forward the narration of the main story. Hence, failure to progress in the game will not create a psychological counter-effect, de-motivating the user.

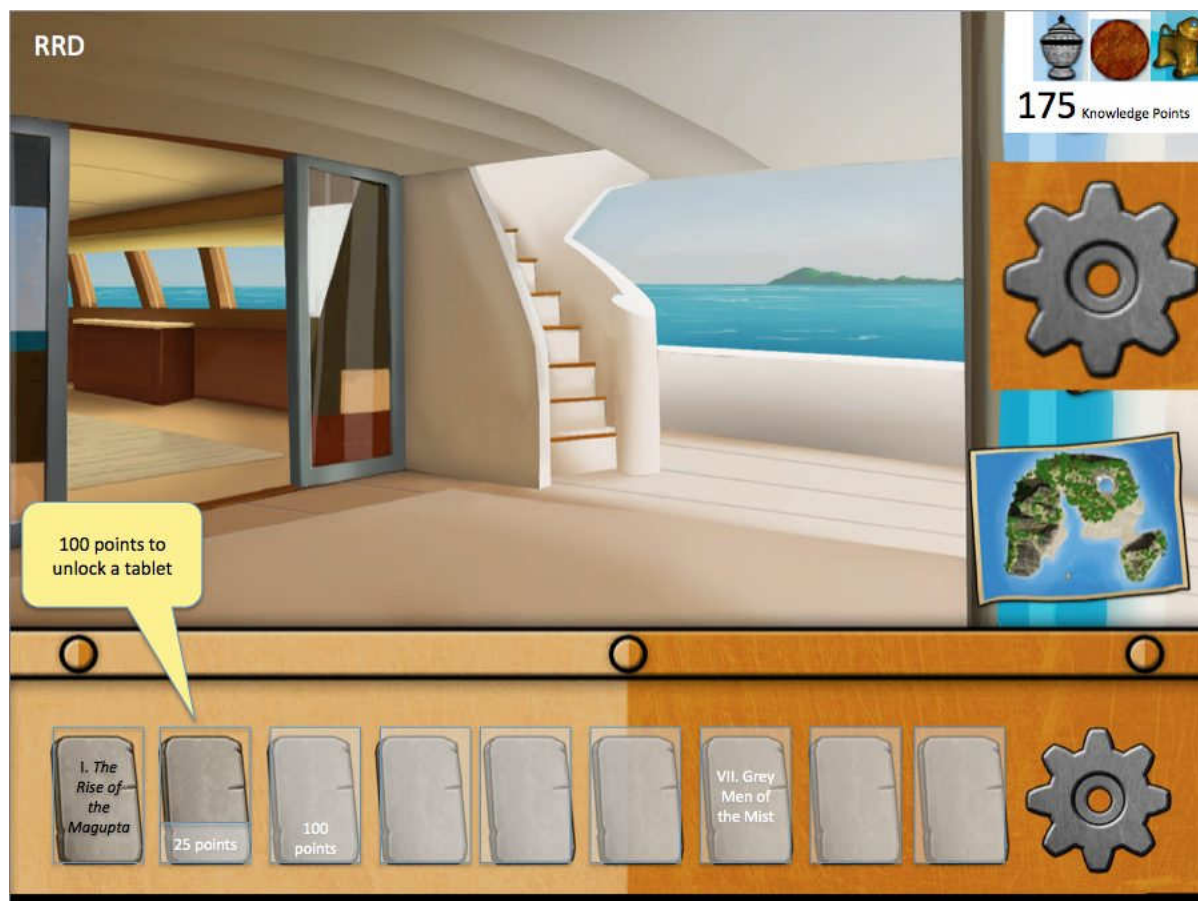


Figure 1: The ship's main screen

For the chronic pain rehabilitation game, the patient and therapist will have access to an overview of the outcome of the various mini-games played. That way, the patient and therapist can evaluate and adjust the patient's baseline on a game-to-game basis.

For the same game a calibration scene has been set up. This is meant to measure (calibrate) the player's physical vantage point in the various exercises and use this information to set the difficulty of the mini-games. The baseline that is calibrated the first time the player enters the game will be adjusted after each play session, thus increasing the difficulty as the patient improves her mobility. This is an automatic adjustment of the game difficulty to the patient's level of progress. Ultimately the patient will be able to reach the mobility goal set by the therapist during the first calibration.



Figure 2: Player motion-capture calibration screen in the pain rehabilitation game

4 The island

This is where the different mini-games are to be found. The island is a 3D environment where the avatar can walk around, exploring the tranquil tropical setting, and access the mini-games from specific locations on the island.

Either patient group will be able to access the three games that have been made specifically for them. On the map the player will be informed where on the island the mini-games can be found.

- The lake: *The Temple of Magupta* mini-game
- The beach: *Treasures of the Sea* and *The Three Wind Gods* mini-games
- The cliff: *The Face of Cronos* (2 versions)
- The hill: Sign of the Magupta



Figure 3: Wandering in the island

Each time the patient has completed a task (mini-game), she can choose either to return to the ship (to inspect her findings), repeat the mini-game, or walk to one of the other locations / mini-games. There are visible paths on the island connecting each of the mini-game locations.

The function of the map is to show the player where on the island the various mini-games can be found. Also, since the RRD patients will be controlling the game by speech commands, they will use the map to access the three mini-games directly, rather than navigating their avatars in the 3D island scene to the mini-game triggering locations.

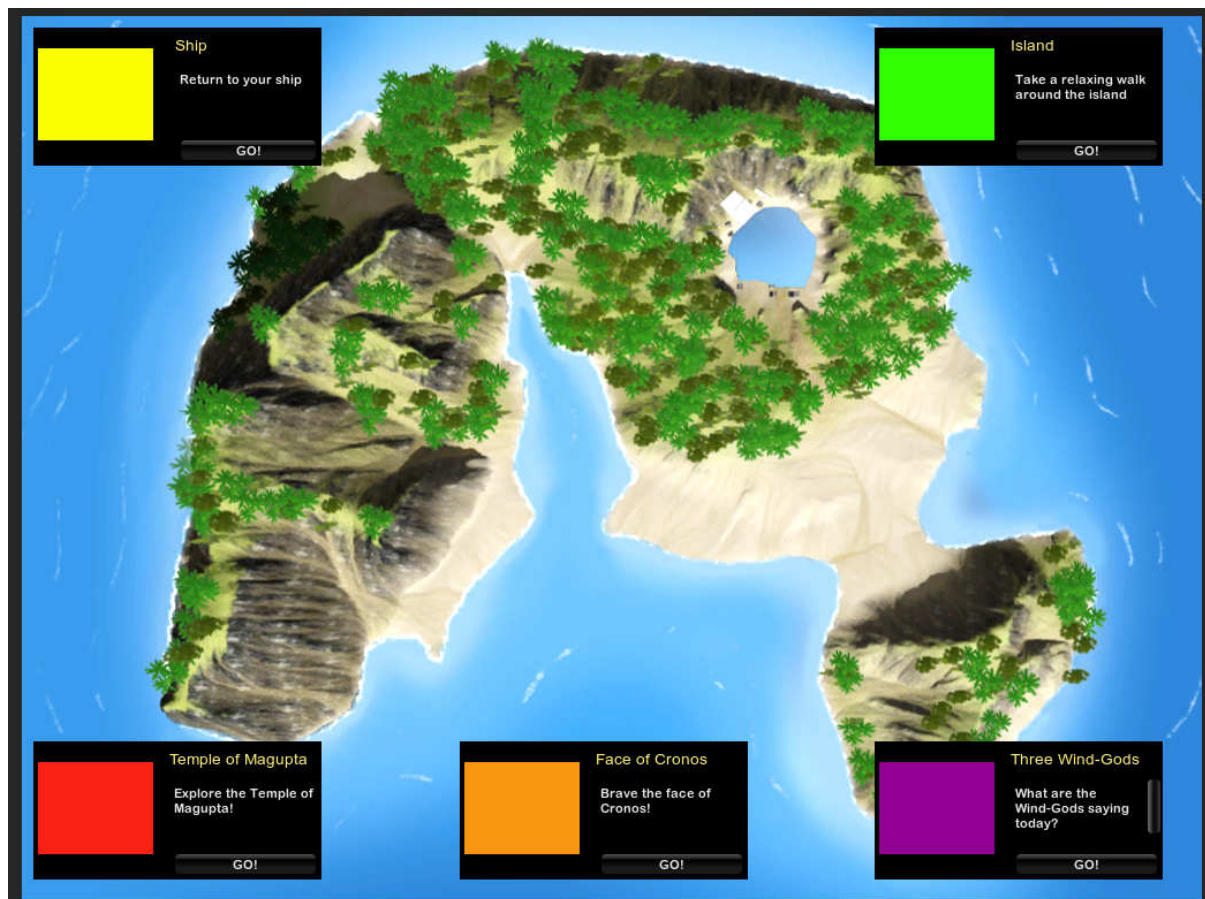


Figure 4: The island map that the player can use to directly initiate a mini-game by skipping moving to its triggering location in the island's scene.

5 Mini-game 1: The Temple of Magupta

This mini-game is about exploring the ancient temple located on the island. This is done to learn more about the Magupta Empire, by discovering artifacts inside the temple. To start the mini-game the player goes to the temple location and clicks the temple entrance, or chooses the temple location from the map.

5.1 Game Play

The Point of View is third-person, where the avatar, with his back to the player, walks down a straight tunnel path. The path is split into five invisible lanes. At any time, the player may command his avatar to change lane to the left or right, except if he is already in the leftmost or rightmost lane respectively. The goal for the player is to reach the room at the end of the tunnel within the given time. Along the path the player should pick up artifacts laying on the ground of the tunnel, while at the same time avoiding obstacles, such as holes in the floor and falling debris. Artifacts and obstacles may be found in any of the five invisible lanes. The player may have to change lanes frequently, in order to avoid obstacles in the current lane and to pick up approaching artifacts in other lanes.

The inside of the Magupta temple is a broad, straight tunnel, with a very ruinous look. The place is poorly lit, but kept in strong colors. The style fits the avatar and the rest of the island, and is as realistic as possible.

5.1.1 Incentives-Rewards

By reproducing the sounds correctly, the player will proceed to the next level. The higher the level the player can complete, the more points she gets. Successfully completing all the levels will award the player with artifacts.

Regarding rewards, there are two kinds of basic rewards in the game. Artifacts, which are objects left by the Maguptas (animal figures, golden coins, urns) and tablets (stone tablets with carvings). The artifacts are graphical rewards while the tablets are narrative rewards.

Artifacts

At different intervals, the player will come across artifacts littering the tunnel floor. To pick up an artifact, the player simply moves her avatar to the lane where the artifact is located and moves over it. By doing this, the artifact is picked up.

There are 3 different types of artifacts in the temple, with various rarity. The rare artifacts are harder to get (the avatar will need more speed to reach it before it sinks; they also spawn more rarely), but also give more points. On screen, the player will have a counter for each of these artefact types. These counters have three intervals, and each time an artifact is picked up, the corresponding counter raises one interval. When a counter is full, the player will get extra points, and be closer to unlocking another tablet.

Tablets

On the ship the player will have nine locked tablets. By gathering artifacts in the mini-games, and scoring points, the player will gradually un-lock more and more of these tablets. The tablets contain some of the story of the Magupta Empire. There are a total of nine tablets, comprising the entire history of the empire.

5.1.2 Obstacles-Challenges

Sinking artifacts

Due to the tricky nature of the temple structure, artifacts have a tendency to disappear in the floor (sinkholes). If the player is not walking fast enough, these artifacts will have sunk into the ground before she can reach them. This means that a higher speed will result in more artifacts and subsequently a higher score. The artifacts can sink at three speed levels: sink speed 0 (they don't sink, so the player will always be able to pick them up), sink speed 1 (player need to perform at 95% to reach artifact in time), sink speed 2 (player need to perform at 120% to reach artifact in time).

Holes in the ground

The holes are placed on the different lanes. They will be easily identifiable as hindrances. If the player runs across a hole, she will loose 5 speed points.

Debris

At certain points, rubble will start falling from the ceiling. If the player runs through falling rubble, she will lose 5 speed points.

5.2 Game I/O

The patient, while wearing the motion capture suit and EMG pads, walks on the treadmill. The motion capture system around the player is optically capturing the player's motions and after recognizing the motions feeds this structured information to the game engine. The patient can make the avatar change lane by using voice commands (*left, right*).

Speed

At the calibration, the player's speed level is set. This speed level corresponds to the game speed of the avatar, not the actual speed of the patient, and it is an indicator of the speed level that should be achieved by the player in the mini-game to be successful. This speed level is informed from the patient's baseline, and is individually computed. In the updated D2.4 deliverable, section 6.2 Chronic Pain, the Mo-Cap algorithm for computing the walking speed from feet-attached POIs is documented. There are two speed indicators in the game. One used by the avatar (the character in the game), and one used by the player (the speed the patient walks with on the treadmill). Thus, if the player keeps a steady, high speed on the treadmill, the avatar's speed in the game will keep increasing.

The avatar's speed indicator is a gradient, which slowly increases or decreases as the avatar gains or loses speed. The player's speed indicator has three levels: red, yellow or green.

Red speed level: This speed level has two functions.

Before the game begins: The game will not begin before the player has reached a certain speed (her baseline speed). This will bring the needle in the speed indicator into the yellow section.

After the game has begun: As long as the player's speed is in the red level, the avatar's speed will decrease.

Yellow speed level: This speed interval is from 10% below baseline to 10% above baseline. As long as the player keeps within this interval, the avatar speed will not change.

Green speed level: This speed interval is from 10% above baseline speed up to 6km/h. As long as the player keeps within this interval, the avatar speed will increase (until it reaches maximum).

To complete the mini-game (reaching the end of the tunnel in time), the player will have to keep an average speed equal to the baseline speed.

5.3 Expected and unexpected user reaction, benefits and risks in the mini-game design

The in-game character (the avatar) increases her speed if the patient reaches the calibrated baseline speed or higher. At the same time as keeping her speed at the baseline level (or higher), the player will also have to avoid obstacles in the temple while gathering artifacts. If the patient runs into an obstacle the avatar will loose speed. This will force the patient to increase her speed on the treadmill to make the avatar regain the lost speed. This is done in order for the avatar to reach the end of the tunnel before the time runs out. Success will be achieved if the player can keep a minimum speed (the baseline) for a duration set by the therapist. The avatar will then reach the end of the tunnel and will be rewarded with the artifacts found. Finding enough artifacts will eventually unlock one or more of the tablets aboard the ship.

Each of the mini-game mechanisms is designed in a manner where the player feels forced to work with one of the targets less susceptible to change through a more traditional CBT therapy.

Table 2: Game mechanisms and patient reaction for The Temple of Magupta

Game mechanism	Therapy/Game objective	Expected patient behaviour	Unexpected patient behaviour	Game response
Walking/Running game: direct mapping between player and avatar actuations	Improve physical condition	Relate to avatar and immerse in game world		
Game avatar accelerates/decelerates if current player speed is over/below baseline speed	Self-awareness of the baseline speed as an exercise reference goal	Keep at least baseline speed	Inability to follow baseline speed, falling from treadmill, standing aside from treadmill	Deceleration of avatar speed.
Game level time limit: Player has to gather as much artifacts as possible	Motivation for increased step frequency and walking velocity		Increasing step frequency	
Approaching obstacles in player's lane	Achieving an uninterrupted walking pace	Coordinate voice with stepping frequency while commanding changing lanes, keep steady walking pace	Distraction from stepping function or Voice ASR being too slow or unable to process command or avatar walking speed too high	
Sinking artifacts in player's lane	Increase acceleration	Achieve a higher walking velocity or a walking acceleration and pick up objects		

Avatar speed decreases when bumping into an obstacle				

5.4 Implementation Status

The final version of this mini-game has been made and tested by partners RRD and TUW. It is included in the release-version of the pain rehabilitation game.



Figure 5: “The Temple of Magupta” mini-game

6 Mini-game 2: Treasures of the Sea

In this game the player explores an underwater location where different items can be found on the ocean floor. These will be artifacts from the lost Magupta empire. The player has an oxygen level, which indicates how long she can stay under water. The player's emotions will influence how fast the oxygen decreases. Boredom will increase the drop rate slightly, whereas anger will increase the drop rate even further.

6.1 Game Play

At a specific location on the beach, the player enters the ocean. As soon as she dives beneath the waves, the point of view changes to first person view. Inside the underwater sea basin, artifacts from the lost Magupta civilization can be found in various (random) places. When an object is located, the player swims to it and picks it up by clicking it with the mouse cursor. The player will have to manage her oxygen level to stay under water as long as possible. If she runs out of oxygen she has to return to the beach. Besides artifacts the player will also be able to find balloon fish. Catching a balloon fish will increase the player's oxygen, thus allowing her to stay under water longer.

The objective for the player is to gather artifacts, but also catch a balloon fish now and then to increase her oxygen level. The balloon fish are not easily caught, since they respond to the player's emotional state. If the player becomes either angry or bored, the fish will flee or disappear. The player then has to calm herself to be able to once again catch the fish. The game will both reward success (gathering artifacts) and effort (time spent diving) to avoid too strong a focus on the competitive aspects.

The skills that the therapists request from the player to demonstrate are to be calm and relaxed, to tolerate frustration and anger and to plan in advance. These skills are mapped to game mechanisms. Fleeing balloon fish will trigger frustration and tension, and induce excitement and anger. The dispersed artifacts call for the player to plan carefully her swimming route in the underwater basin so as not to waste too

much oxygen since it is constantly depleting. The player goal is to gather as many objects as possible and stay as long under water as possible. The player must apply self-control and stay relaxed, to complete the mini-game goal.

The oxygen and the behaviour of the fish are all controlled by the emotions and heart rate of the player. The oxygen, which allows the player to stay under water, slowly drops during the entire game. The oxygen drops with 1% / sec. during normal conditions. As the player's heart rate increases, so does the oxygen drop rate. If the patient's heart rate is 10% above baseline, the oxygen drop rate increases to 2% / sec. If the heart rate reaches 20% above baseline, the oxygen drop rate will increase to 3% / sec. (we will have to test to decide on the precise %-divisions).

The balloon fish are affected by the player's emotions. If the player is bored, the balloon fish will flee from the player if approached. If the player is angry, the balloon fish will blow up if approached. If the player successfully picks up a balloon fish, the oxygen level will increase with 30%.

At the start of the game, 3 artifacts and 5 balloon fish will spawn at random spots in the under water location (there are a total of 15 spawn points, where they can appear). If the patient picks up a fish, a new fish will spawn elsewhere. Same with the artefacts, so that there will always be 3 artifacts and 5 balloon fish.

6.1.1 Incentives-Rewards

There are two kinds of basic rewards in the game. Artifacts, which are objects left by the Maguptas (animal figures, golden coins, urns) and tablets (stone tablets with carvings). The artifacts are graphical rewards while the tablets are narrative rewards. Besides rewarding the player for the number of artifacts gathered during the dive, the game will also reward effort (to remove some of the focus from the competitive aspect). The player will, after completing a dive, be rewarded with bonus artifacts dependent on the time spent under water (ignoring whether the player was successful or not in collecting artifacts).

Artifacts

The will swim towards the artifacts that are found under water. When close enough, the player can click the artifact to pick it up.

Tablets

On the ship the player will have nine locked tablets. By gathering artifacts in the mini-games, the player will gradually un-lock more and more of these tablets. The tablets contain some of the story of the Magupta Empire. There are a total of nine tablets, comprising the entire history of the empire.

Balloon fish

There will also be balloon fish in the water that the player can catch and use to get new oxygen. Catching and using a balloon fish will increase the player's oxygen level, thus enabling her to stay under water for an extended period of time. The balloon fish moves away from the player when the player gets emotional. So they have to learn to staying calm to catch the balloon fish, is part of the exercise. It is not possible to catch balloon fish while angry or bored, so the player will have to regain a calm state before proceeding. Again, by using this type of strategy, the wished performance of end users (to remain calm) will be positively reinforced (following typical learning theory of behaviours).

The diving game has 10 levels. Each level will spawn a number of artifacts ($5 + \text{level number}$) and a number of balloon fish ($20 \div \text{number of artifacts}$). Both artifacts and balloon fish will spawn at random spots in the under water location (there are a total of 43 spawn points, where they can appear).

When a level has been completed, the player will receive points based on the number of artifacts gathered.

6.1.2 Obstacles-Challenges

Balloon fish

The balloon fish both function as a reward and as an obstacle. Balloon fish are a very sensitive species. They don't respond well to negative emotions (i.e. boredom, anger), and tend to flee or explode, if they sense those kinds of emotions.

Planning

To administer the oxygen level, the player has to consider where to go next. The planning involved would include deciding for a good route between balloon fish and artifacts, so as to stay under water as long as possible.

Frustration, tension, excitement, anger: The tension and excitement is induced through the slowly dropping of the oxygen, and the continuous struggle for the player to both gather items from the ocean floor and at the same time keep the oxygen level up. Frustration will occur when the player in an attempt to get more oxygen from the balloon fish scares them away with her negative emotions.

6.2 Game I/O

The player can swim around in the under water location, using keyboard and mouse for controlling the player's avatar in the game.

Emotion recognition is used in this game, as a combined way to judge the player's calmness, boredom and anger.

The game's output is visual (game feedback through the screen) and acoustic (through feedback sounds audible at various stages of the game).

6.3 Expected and unexpected user reaction, benefits and risks in the mini-game design

Each task is designed in a manner where the player feels forced to work with one of the targets less susceptible to change through a more traditional CBT therapy.

Table 3: Game mechanisms and patient reaction for Treasures of the Sea

Game mechanism	Therapy/Game objective	Expected patient behaviour	Unexpected patient behaviour	Game response
Catching artifacts dispersed on the sea bottom	Provide an attractive motivation/challenge	Start swimming towards artifacts	Remaining idle	Oxygen tube game mechanism in effect

Oxygen tube = limited time to complete level	Provoke frustration and let the patient deal with it	Start planning swimming paths to maximize artifacts gathering	Demonstrate impulsivity in the form of greed	Oxygen tube game mechanism in effect
Catching balloon fishes to extend available oxygen = extend time to complete level	Provide an additional motivation and reward mechanism	Improve planning underwater paths to strategically combine artifacts and balloon fishes for maximum reward	Demonstrate impulsivity for both artifacts and fishes	Balloon reaction to player emotions in effect
Balloon fishes react to player's emotional state (the flee when the player is not calm)	Motivation to experience and sustain calmness (relaxation)	Learn to control extreme emotions and stay calm	Avoid self-control, surrender to impulsivity or negative emotions	Balloon reaction to player emotions in effect, Oxygen tube game mechanism in effect

6.4 Implementation Status

The final version of this mini-game for mental health disorders had been made.

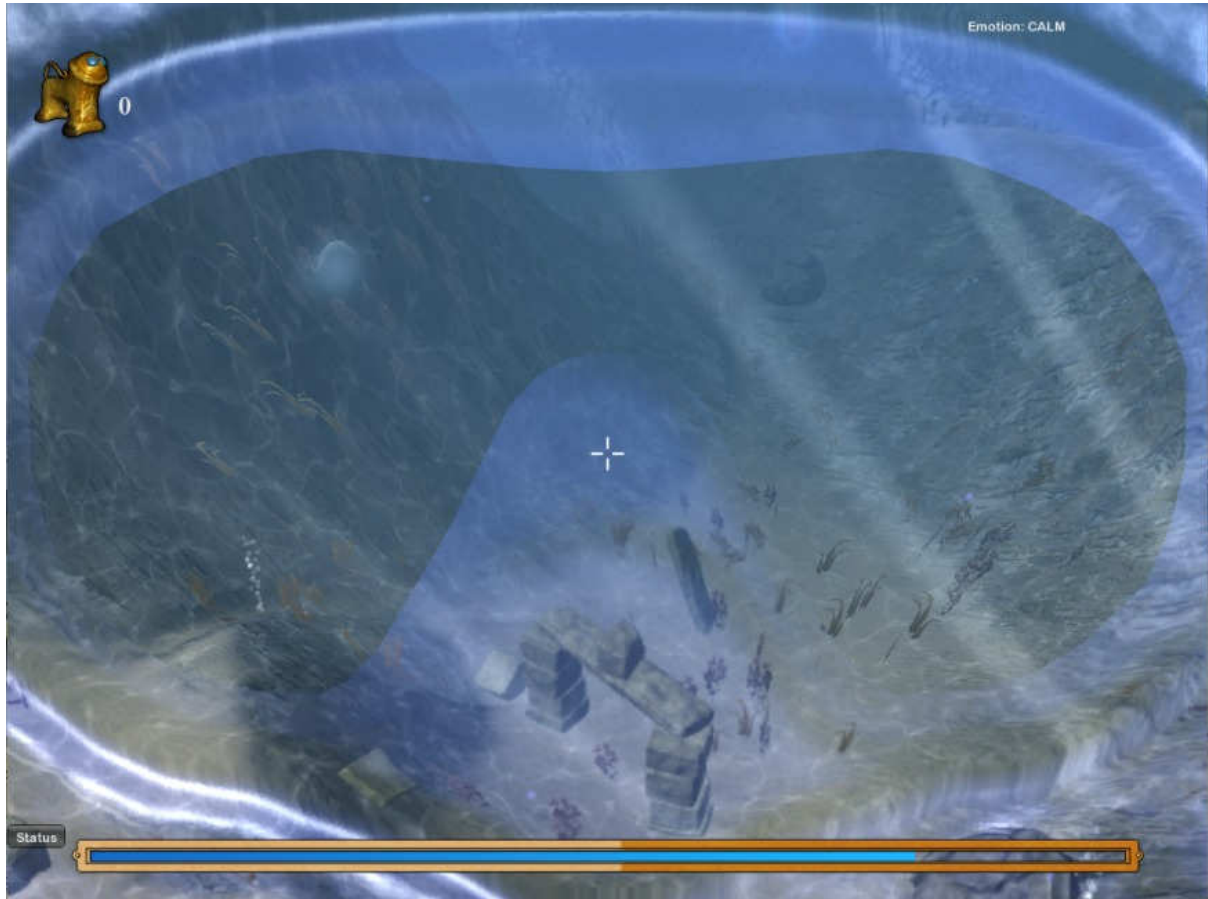


Figure 6: The “Treasures of the Sea” mini-game

7 Mini-game 3: The Three Wind Gods

On the beach there will be a small stone structure with different wind 'pipes'. By activating the sound of the wind pipes in the right order the player will be rewarded with artifacts. By doing this task the player pays tribute to the old wind gods of Magupta.

This mini-game is for the cervical ROM exercise, where the patient will be looking away from the screen for a considerable amount of time. Therefore, the game centers on sound response to the players motion.

7.1 Game Play

The player moves to the location at the beach, where the Wind Gods can be found. By approaching the Gods, the mini-game will begin. In the game, the player will use the three cervical movements to create 'tributary' sounds to the wind gods. First, the player will hear a number of sounds, and then, by using the cervical exercises, she will reproduce the sounds heard. Each level of the game will increase the number of repetitions that the player has to do.

The game is divided into a number of levels. Each level contains a number of motions ('yes', 'no', or 'tilt') the order of which the player has to replicate successfully to advance to the next level. Completing all levels will complete the mini-game. Each motion can be identified by its unique sound. The game supplies a series of these sounds as an audible indication of the order of motions.

At each new level the player has to do $n + 1$ random motions (n = number of motions done in the previous level). The motions done in the previous levels are repeated, and one new motion is added. (The names of the motions correspond to the names of the wind-gods in the game).

Level 1: Da

Level 2: Da, Mi

Level 3: Da, Mi, Mi

Level 4: Da, Mi, Mi, Go

In the above example of game levels, the previous motions are repeated in the following levels, and new motions are added. If the example above displayed the entire motion levels of a mini-game, it would hold a total of 10 repetitions. Since the number of repetitions has to match the increasing levels, the repetitions has to be within brackets:

Number of repetitions	Levels
1	1
3	2
6	3
10	4
15	5
21	6
...	...

This means that if the therapist types in for example 12 repetitions in the calibration, the game will, in this case, automatically add 3 repetitions to get to the nearest, full, level – in this case 15 repetitions for level 5. The game will always round up the repetitions to reach the nearest level.

The correct completion of a motion entails that a) the player does the right motion, b) the angle between extreme positions in a motion is equal to the current baseline for that particular motion, and c) the patient does the motion at a steady pace (actual speed is not relevant, but keeping the same speed during a motion is). If any of these three parameters is not met, the motion is registered as failed and the player will have to try again. Failing a level does not mean the player has to start the mini-game all over, but only that s/he has to redo the current level until successful.

Sound and Graphics

On the screen the player will see the windpipes, and next to these the three wind gods will be placed. A wooden stick in the ground atop of which a skull is sitting represents each god. A small sign on each stick tells the name of each god ('Mi', 'Da', 'Go' - the three aspects of the entire god Midago). By saying the skull-names out loud the named skull will turn in the appropriate way (according to one of the cervical exercises), and play the sound that goes with the movement. That way the player will know which movement produces which sound. To indicate when the player has reached the required ROM for each movement, a brief 'scoring' sound will play. Each level functions in the same way. At the start of the level the player will hear the sounds that she needs to reproduce.

7.1.1 Incentives-Rewards

By reproducing the sounds correctly, the player will proceed to the next level. The higher the level the player can complete, the more points she gets. Successfully completing all the levels will award the player with artifacts.

7.1.2 Obstacles-Challenges

The game is divided into various levels where the player has to do the same movements as the gods. The higher the level, the more movements have to be replicated. The movements are chosen randomly, but the game ensures that the right number of each of the movements have been chosen, when the game ends. The "right number" is based on the number of repetitions indicated by the patient or therapist during the calibration.

7.2 Game I/O

In "The three Wind Gods", motion capture is used to capture the upper body motion of the player, especially the cervical motion direction and ROM.

Each god's movement has a specific sound to make a clear audible division between them. This has been done since the player will not be looking at the screen while turning her head.

As a visual cue, each of the three God skulls is turned to the direction of the cervical motion that corresponds to the represented wind God.

7.3 Expected and unexpected user reaction, benefits and risks in the mini-game design

Each mechanism is targeting a therapeutic or game objective. Game objectives are promoting the player immersion in the game, motivation and entertainment (fun) that is needed to sustain the game play experience.

Table 4: Game mechanisms and patient reaction for The three Wind Gods

Game mechanism	Therapy/Game objective	Expected patient behaviour	Unexpected patient behaviour	Game response
Mysterious contraption comprised of 3 wind pipes	Provide an attractive motivation/challenge	Get attracted to the concept, be motivated to explore the mechanism of this mini-game	The patient is confused	Need to explain the purpose of the game
God sound is heard, different for each of the 3 god figures	Letting the patient identify each god with an acoustic cue	The patient maps each god to acoustic cues	Failing to link sounds to wind pipe god head	
God sound is heard, God head turns	Letting the patient identify each acoustic cue with respective cervical motion	The patient maps acoustic cues to cervical motions (directions)	The patient is confused	
Play scoring sound after successful patient motion	Letting the patient recognize the successful threshold of	The patient learns to practice correctly each exercise	The patient learns to practice correctly each	

	cervical motions in terms of range and speed		exercise	
The patient gains artifacts upon completion of a game level and can proceed to the next	Main game reward, motivation to keep the patient on playing the game			

7.4 Implementation Status

The final version of this mini-game has been made and tested by partners RRD and TUW.



Figure 7: The three Wind Gods mini-game

8 Mini-game 4: The face of Cronos (mental health version)

The player sets off to climb the cliff wall (that is located on the left side of the island, when viewed from the ship).

The face of Cronos are two mini-games both of which are based around the same thematic concept: cliff climbing. The games use different graphics, game play style and configuration of the game inputs. The pain rehabilitation version of “The Face of Cronos” is described in section 9.

The mental health game configuration demands demonstration of focus and calmness from the player that is performing it. Anger, lack of focus (i.e. boredom), becoming excited, or similar responses, can all easily lead to disaster.

8.1 Game Play

The game is in 2D and is about planning a path up the cliff, which is made of a 7x7 matrix. Starting from the bottom row, the player places spikes on the cliff wall to mark a path to the top row. At various places on the cliff, there will be artifacts and spikes, which the player can pick up, to make the climb more successful. The game will both reward success (gathering artifacts) and effort (placing spikes), to avoid too strong a focus on the competitive aspects. The game play consists of 2 turns, a planning turn and a resolution turn.

During the planning turn, the player puts spikes in adjacent cells taking care to have enough spikes left to reach the top of the matrix. Obstacles during that phase are immobile at their given starting locations (top-most row for rocks, left-most column for birds).

During the resolution turn, an animation is starting by moving the avatar’s head cell by cell, following the selected path. If the player gets either bored or angry obstacles will begin to appear in the shape of falling rocks and birds flying by. During this

animation turn, the courses of the avatar while climbing the rock may collide with the animation of obstacles that are introduced in the game. If the player enters a cell with either a bird or a rock, the game ends and she will have to start over. If the player can calm herself, the rocks and birds will disappear, and her chance of success will drastically improve.

The player must plan a route up the cliff, while managing her resources (spikes needed to get to the top) and rewards (artifacts gathered along the way). Each cliff is created randomly and thereby different. Each cliff will consist of 9 artifacts that the player can pick up and 3-5 stacks of extra spikes, each containing 3-5 spikes. The player starts out with 5 spikes, forcing her to pick up extra spikes, if she wants to reach the top of the cliff.

Based on the player's emotions and heart rate, horizontal obstacles might spawn during the game. Seagulls will spawn if the player's heart rate increases above the baseline:

HR 0-15% above baseline: no obstacle

HR 16%-24% above baseline: 1 obstacle (seagull) spawn

HR more than 24% above baseline: 2 obstacles (seagull) spawn

In the same way, but based on the player's emotion, vertical obstacles will spawn, in the shape of falling rocks:

Player gets bored: 1 obstacle (rock) will spawn

Player gets angry: 2 obstacles (rock) will spawn

The obstacles are not moving during the planning phase, but the player will have to take them into account during planning, or try to relax to make them disappear. When the player press "Start" the climb will begin and all input is locked. This means that any changes in the player's emotion or heart rate after this point, will not affect the game.

8.1.1 Incentives-Rewards

Reaching the top will award the player with bonus artifacts. Gathering enough artifacts will eventually unlock tablets aboard the ship. Besides rewarding the player for the number of artifacts gathered during the climb, the game will also reward effort (to remove some of the focus from the competitive aspect). After a climb has been done, the player will be rewarded with bonus artifacts, based on the number of spikes she has placed (ignoring whether the player was successful or not in collecting artifacts).

8.1.2 Obstacles-Challenges

Frustration, tension, excitement anger: The risk of not making it to the top, or the emotions producing obstacles, will both generate excitement and tension in the light of possible success and failure, and frustration, when the player actually fails. The lure of quick reward lies in just putting in the spikes to progress the climbing, and not care about calming yourself before making a decision. This approach will produce obstacles (seagull, rock) that will decrease the chance of success considerably.

Increasing difficulty: The difficulty is increased by the player's emotions. If the player remains calm during the climb she will most likely reach the top without problems. But the risk of failure will easily change the player's emotion, thus generating obstacles.

8.2 Game I/O

The player's emotional response affects this mini-game's game play. Emotional response is measured by 3 individual components, from spontaneous speech, from facial gestures and from physiological changes. The project is measuring three emotion classes namely calmness, anger and boredom. Based on the player's emotional response the game will increase in difficulty. Her goal is to reach the top of

the cliff without falling down. The mental health game is a 2D game (from a third person perspective).

8.3 Expected and unexpected user reaction, benefits and risks in the mini-game design

Each game mechanism is designed in a manner where the player feels forced to work with one of the targets less susceptible to change through a more traditional CBT therapy.

Table 5: Game mechanisms and patient reaction for The Face of Cronos (mental health version)

Game mechanism	Therapy/Game objective	Expected patient behaviour	Unexpected patient behaviour	Game response
2D grid including cells containing symbols of spikes or artifacts, “reach at the top” as the goal	Easy to grasp concept that will motivate the patient to start playing	The patient starts playing the game	The patient seems confused or bored	
Limited number of available spikes, difficulty gathering all artifacts	Provoke frustration and let the patient deal with it	Start planning grid paths in order to minimize steps to reach at the top of the grid	Demonstrate loose planning skill	Failure condition in effect
Failure condition: when no spikes are available and the player has not reached at the top	Provoke motivation if seen as a challenge	Always pay attention to number of available spikes as a condition of win/failure	Failure to focus on the single important win/failure condition	Failure condition in effect

A rope ties the steps of the player	Facilitate as much as possible the planning process to the user: Past moves visualisation	To improve forward planning		
When the player's path passes through a spikes symbol, the player will gain 3-5 more spikes	Provide an additional motivation and reward mechanism	Improve planning path to strategically combine artifacts and spikes for maximum reward	Demonstrate impulsivity for both artifacts and spikes	Failure condition in effect

8.4 Implementation Status

The final version of this mini-game for mental health disorders had been made.



Figure 8: "The Face of Cronos" mini-game (mental health version) during the planning turn (no spikes have been placed yet)

9 Mini-game 5: The face of Cronos (pain rehabilitation version)

The player sets off to climb the cliff wall (that is located on the left side of the island, when viewed from the ship).

The chronic pain rehabilitation configuration of this mini-game is for the reaching exercise taking into account the shoulder stress/relaxation.

9.1 Game Play

The patient stands on the ground and reaches above her head with either arm. By using voice commands, the player chooses which arm to move ("Left" or "Right"). The player then starts reaching for the next handhold /ledge (where an artifact can be picked up). The distance to the handhold is equal to the current baseline.

When the player is done with a reach, the avatar, which is climbing the in-game cliff, will climb one level higher up. Due to the number of repetitions set by the therapist during calibration, the patient will have a certain number of reaches she can use to reach the top of the cliff. To be able to reach the top within the limited number of reaches the player has to reach a certain height every time. Reaching the top will award the player with bonus artifacts, which will eventually unlock tablets.

The player has a certain number of moves to try reaching the top of the cliff. The number of repetitions set during calibration defines the number of moves available to the player. Each move done will subtract one from the number of moves left, no matter how successful it was. To be able to reach the top of the cliff, the player will have to reach an average of the calibrated height during the climb. Reaching lower than the baseline on one move will force the player to push him-/herself more on the following attempts. Not reaching the top of the cliff will force the player to start over.

During the climb, the player will be notified if his/her muscle tension exceeds 20% at which point s/he is encouraged to relax before continuing. The current muscle

tension is visible on screen at all times, which allows the patient to also relax between reaching.

9.1.1 Incentives-Rewards

Based on the calibration (current baseline), the player will have a certain number of attempts (reaches) to get to the top. The player will be awarded every time a reach is at baseline height or better. This way the player gathers artifacts to eventually unlock the next tablet.

9.1.2 Obstacles-Challenges

To succeed the player has to achieve baseline height with every reach. If a reach goes below baseline, the following attempts will have to compensate. This might be easy at first, but the player will become tired which will gradually increase the difficulty. As will the number of repetitions entered during calibration by the therapist. The calibration will allow the therapist to adjust both the number of repetitions (increase / decrease difficulty) and the height of each reach (increase / decrease difficulty).

9.2 Game I/O

The pain rehabilitation game is a 3D game in a third-person view, where the patient stands on the ground and reaches above her head with either arm. This will get the avatar, which is climbing the cliff, to also reach and climb.

Motion capture is used for the reaching therapeutical exercise, while EMG for the shoulder relaxation exercise. EMG integration is not yet available in the beta version of this mini-game.

9.3 Expected and unexpected user reaction, benefits and risks in the mini-game design

Each mechanism is targeting a therapeutic or game objective. Game objectives are promoting the player immersion in the game, motivation and entertainment (fun) that is needed to sustain the game play experience.

Table 6: Game mechanisms and patient reaction for The Face of Cronos (pain rehabilitation version)

Game mechanism	Therapy/Game objective	Expected patient behaviour	Unexpected patient behaviour	Game response
The avatar attached to a cliff, hands and feet firmly attached to the wall	Easy to grasp concept that will motivate the patient to start playing	The patient starts playing the game	The patient seems confused or bored	
Failure condition: the player's avatar falls to the ground and the mini-game ends	Motivation to practice motions with advised range and speed	The patient is practicing motions with advised range and speed	The patient does not avoid the failure condition	Failure condition in action
Moving forward in the mini-game means reaching the next ledge /artefact	Learn to reach the required (calibrated) height	The patient learns to map reaching to pick up artifact in the game with physical reaching a distance	The player fails at correctly understanding/predicting game distances with real distances	The player's avatar will advance less than needed in order to complete this level
The player/expert chooses the climbing path (left/right)	Adapting to patient needs, the expert may dictate which hand needs more practise	Follow the therapist guidance	Ignore the therapist guidance and choose on her own	The game stays indifferent since it does not know the therapeutic program
The patient prompts "Stop"	Self-awareness of range and speed	The patient explicitly marks		

when the required motion has been correctly performed	of motion	the finish of a reaching motion at its maximum extent.		
Reaching the top rewards the player with artifacts, in proportion with the success during the climb	Patient reward mechanism, as a motivation to reach the end of the level and complete this set of exercises	The patient strives to get the reward	The patient stays indifferent of the reward	

9.4 Implementation Status

The final version of this mini-game for pain rehabilitation has been made and tested by partners RRD and TUW.



Figure 9: "The Face of Cronos" mini-game (pain rehabilitation version)

10 Mini-game 6: The sign of the Magupta

10.1 Game Play

In this game the player draws constellations with her breathing. The game will show a part of the night sky. From a collection of possible constellations, one is chosen. The stars of the constellation that the player is about to draw will be glowing brighter. The game decides the order, in which the lines between the stars are drawn. All the player has to do is connect the stars.



Figure 10: The Sign of the Magupta concept art

When the player enters the relaxation game, she will see the night sky. A constellation is chosen, and the first star in the constellation lights up. The player then takes a deep breath, and as she exhales, a line is drawn ('blown') to the next star in the constellation. The line is only complete if the breathing is slow and deep enough. Otherwise, the line will only reach part of the way, and then disappear.

As it is described in deliverable D2.4 (June 2010 version), the skills that are required from the user are achieving and sustaining calmness and relaxation. The

requirement for the game is to let the player relax and calm, and not generate unneeded distraction, confusion or stress. The simple in-game goal for the player is to complete the constellation, by using controlled breathing.

The mini-game consists of seven constellations from the Magupta mythology. The constellations consist of somewhere between 5 and 8 stars, which in a way functions as a “difficulty level”. The more stars, the longer the relaxation period, and the more relaxed the player eventually might become. The more stars in a constellation, the closer the player needs to get her breathing to the calibrated level. This also will increase the relaxation. The variation in time spent and difficulty of each constellation will give the player a chance to pick a constellation that suits her level.

10.1.1 Incentives-Rewards

The game-exercise combines both calming oneself through controlled breathing, and at the same time showing a tranquil and relaxing view, that the player might be able to recall later in a stressful real-life situation; visualizing the drawing of the constellation, will help take her mind off things and make her calmer.

10.1.2 Obstacles-Challenges

The challenge is for the patient to calm herself sufficiently to be able to complete the constellations. The various constellations that are available have a different number of stars, which in a way functions as “difficulty level”. The player can start out with the easier constellations to somewhat calm herself, and then get even more calm by trying one of the larger constellations.

10.2 Game I/O

This game is only using the emotion recognition equipment of PlayMancer. The emotional states of the player are triggering the game mechanisms appropriately, in accordance with the rules of the game design (as in above).

During calibration the player’s relaxed respiratory rate is measured. This is the relaxed baseline that this mini-game uses. During the star gazing mini-game, the

player is asked to slow her breathing as much as possible. If she succeeds getting within 0-20% of her calibrated relaxed respiratory rate, the line between the stars will be drawn. If her breathing goes above that, the line between the stars begins to retract. When a line has connected two stars, that progress cannot be lost. The lines will only retract to the last star that it has been connected to. Furthermore, direct input from respiration and heart rate sensors are used in the Sign of Magupta mini-game.

The relaxation task that this mini-game tackles is the most crucial one in the mental disorders CBT therapy. If this does not work for the patients, then the whole game effectiveness is jeopardized since this is the main technique that we have to reduce impulsivity. In addition to bio-signal-based emotional recognition (since the other two components for emotion recognition are not expected to contribute to emotion recognition, the patient is expected to be silent and still), the star gazing mini-game needs to control two physiological parameters: breathing frequency (this should be directly counted in a continuous way, namely breaths/minute) and pulse rate.

10.3 Expected and unexpected user reaction, benefits and risks in the mini-game design

Each game mechanism is designed in a manner where the player feels forced to work with one of the targets less susceptible to change through a more traditional CBT therapy.

Table 7: Game mechanisms and patient reaction for The sign of the Magupta

Game mechanism	Therapy/Game objective	Expected patient behaviour	Unexpected patient behaviour	Game response
The game asks the player what sign to follow from a list of available signs.	Limited patient freedom to select the desired one from a list, interactive element that			

	increases patient engagement			
Tranquil and relaxing setting (3D scene)	The patient might recall later in a stressful real-life situation	To assist the player to relax, to be memorised as a relaxing experience reference point		
Success condition: relaxed exhaling (the game draws a line connecting previous and current stars)	The patient is rewarded for learning techniques to cope with extreme emotional situations	Mastering controlled breathing as a self-relaxation technique	Lack of patience or self-control discipline	
Failure condition: uncontrolled exhaling (the game is starting to draw a line connecting the previous and current stars and then fades away)	The patient is not rewarded for failing to demonstrate techniques to cope with extreme emotional situations	The patient tries again	The patient gets frustrated	

10.4 Implementation Status

The final version of this mini-game for mental health disorders had been made. Further improvements until the start point of the project evaluation with real patients will be reported in an update of this document.

The following screen shot is taken from the final version of this mini-game:



Figure 11: "The Sign of the Magupta" mini-game

11 Conclusion and Next Steps

In this document the final Playmancer game prototypes have been described. The following paragraphs summarise the development status and provide an outlook on the next steps.

11.1 Integration with Speech ASR, Emotion recognition and Motion capture components

Integration of the 2 PlayMancer games with the devices that measure the player's motion (motion capture system), the player's emotion states (emotion recognition camera, bio-harness and microphones) is not a task included in WP5, of which Work Package this document is part of. The final versions of the playmancer games have been already integrated with the 2 main technologies for the two end user audiences: motion capture for the pain rehabilitation game, and emotion recognition for the mental health game. Fusion accuracy and user acceptance are assessed in project deliverables D3.1, D8.1 and D8.2.

The final version is ready for both PlayMancer games. Each one includes the final version of three different mini-games, plus the shared ship scene and island map and world. This release candidate version of the games has been used in the evaluation sessions with real patients, for both games.

An end-to-end prototype of the pain rehabilitation game has been tested with motion capture, and a list of feedback and comments has been compiled from patients and RRD domain experts alike in deliverable D8.1 Part A. An end-to-end prototype of the mental health game has been also tested, documented in its counterpart, Part B. We had similar feedback from demonstrating this system to the audience of the NEM technological platform exhibition (September 2009). Results of all trials with IDIBELL experts and patients are reported in deliverable D8.1 Part B.

11.2 Finalisation of the games implementation and testing

The amended project plan documents that game implementation activities will carry on until the evaluation trials will start for the two end-user groups. This milestone is set for October 2010 and has been met. Until that time, thorough tests with internal play-testers, and domain experts, and preliminary trials with end-users (patients) have continued. This document, D5.6, is updated to reflect the final revisions to mini-game design and whole game flow just before the evaluation trials begin.

Similar improvements in the technological modules that support the 2 games have been delivered in parallel before the starting of the field trials. These are documented in the final and updated version of deliverable D3.3.

12 References

1. PlayMancer deliverable D2.4 “Refined requirements and specifications” (June 2010 version)
2. PlayMancer deliverable D5.5 “Intermediate PlayMancer Games for behavioural and addictive disorders and motor-rehabilitation”
3. PlayMancer deliverable D5.4 “PlayMancer Games development report and manual”
4. PlayMancer deliverable D8.1a “Part A: Intermediate Playmancer evaluation Results – Physical Rehabilitation” (June 2010 version)
5. PlayMancer deliverable D8.1b “Part B: Intermediate Playmancer evaluation Results – behaviour and addictive disorders” (June 2010 version)
6. PlayMancer deliverable D8.2a “Part A: Final Playmancer evaluation Results – Physical Rehabilitation”
7. PlayMancer deliverable D8.2b “Part B: Final Playmancer evaluation Results – behaviour and addictive disorders”
8. F. Fernández-Aranda, (2010), “A serious videogame as additional therapy tool for bulimia nervosa and binge eating disorders: Playmancer multicenter European Project”, in Eating Disorders Research Society 16th Annual Meeting, October 7-9, 2010, Cambridge, Massachusetts, USA
9. F. Fernández-Aranda, (2010), “A Serious Videogame as Additional Therapy Tool for Pathological Gambling: Playmancer Multicenter European Project”, in Annual NCRG Conference on Gambling and Addiction: Redefining Diagnosis, Treatment, Research and Responsible Gaming for the 21st Century, November 14-15, 2010, Las Vegas, USA