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*Dissemination Level:
PU=Public
PP=Restricted to other program participants (including Commission Services)
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**Nature of Deliverables:
R=Report
P=Prototype
D=Demonstrator
O=Other

Abstract

Deliverable 5.3 'Exergames' provides a description of the whole Exercise Area used in the gamified environment (presented in D5.2) to present to the DOREMI users the physical protocol, both indoor and outdoor.

The main aim of deliverable D5.3 is to outline the integrated prototype of the whole application, and describe in detail the process, functionalities and clinical aspects of the Exercise Area. Technical aspects are also presented to show how the DOREMI application communicates with the game server and with the KIOLA server.

D5.3, 5.4 and 5.5 can be seen as three 'twin documents', intentionally following the same structure. These three documents describe in detail the content of the DOREMI application, the integrated working prototype containing the Exercise Area (D5.3), the Social Area (D5.4) and the Cognitive area (D5.5).

Keywords

Exergame, gamified environment, physical activity.

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0.2	Antonio Ascolese	Wireframe description	30/09/2015
0.3	Federico Vozzi	Clinical implication	28/09/2015
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0.5	Antonio Ascolese	Integration and minor changes after internal review	03/11/2015
0.6	Antonio Ascolese	Updated with paragraph 4	30/11/2015

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1. ABBREVIATIONS

API - Application Programming Interface
JSON - JavaScript Object Notation
WSN - Wireless Sensor Network
PA - Physical Activity

2. EXECUTIVE SUMMARY

The purpose of WP5 within the DOREMI project was to design and develop the gamified active ageing virtual environment. The virtual environment represents the main access point for the DOREMI end users. Using the DOREMI application on their tablet, users can engage with the virtual environment where different activities, related to the life protocols fine-tuned in WP2, are presented (as in D5.2). The game environment, considering both the clinical requirements and the user motivation and engagement, contains three different areas, specific for each clinical protocol: the Cognitive Area (presented in D5.5), the Exercise area (presented in D5.3) and the Social Area (presented in D5.4). As these three areas are already integrated in a unique app, as in the final version that will be used by the DOREMI end user, an integrated prototype is presented. This working and usable prototype presents the game environment with the whole functionalities studied, designed and developed thanks to the user-centered design (D5.2). From this virtual gamified environment it is possible to access the three areas where the clinical protocols are presented.

The unique prototype (the same for D5.3, D5.4 and D5.5) goes with three different 'twin documents' that help to explain how the prototype works and how it was designed and developed. For all these reasons it was decided to maintain the same structure for the three documents, to cover the same explanation needs. The structure of the three deliverables is:

Section 4 presents one (or more, if necessary) wireframe(s) of the specific area presented in the document. A wireframe is a design document. It is prepared based on: the product guidelines, information collected from users during previous phases of the project, new ideas tested during the DOREMI project, and information on specific issues that arose during the design of the application. These wireframes present the connections between the different functions or sub-sections of the different areas. For this reason, a lot of pictures are presented here. Pictures can represent the application in previous versions, but the main aim is to present the functionalities and the way the application works.

Section 5 presents the clinical aspects of the specific area. All the functions and the elements of the Cognitive Area, the Exercise Area and the Social Area, are designed and developed starting from the clinical protocols fine-tuned and presented in WP2 and every decision was taken in agreement with the clinical partner of the project. Clinical aspects were always considered the most important ones in all the phases of design and development.

Finally, section 6 tries to summarise all the technical decisions of the specific section. In particular, all the aspects involved in the communication process with the Game Server and the KIOLA system are described. This section is divided into two sub-sections; the first one is the common description, which is the same for each of the three deliverables, while the second one is a description of the specific content of each deliverable.

3. INTRODUCTION

In the frame of the DOREMI project, the main objective of WP5 'Development of social and gamified environment' was to design and develop a prototype of a gamified environment to engage users and motivate them to complete the proposed daily activities according to the 'Active Ageing' lifestyle protocols prepared in WP2. This environment will be the access point for users to different sets of cognitive games, social networking, exergames and gamified activities. D5.1 has already described the gamification strategy that has been implemented in the gamified environment (D5.2).

In this context, D5.3 addresses the objective to present a prototype of the Exercise Area. The Exercise Area is the section of the DOREMI application where the clinical protocol for physical activities is presented to the users. This section, similarly to the other two main clinical sections, was designed and developed following a user-centered design process (see D5.1 and D5.2). This approach was utilized to ensure that the DOREMI application is usable and has value to the target group. At the same time, both the design and the development activities were based on the clinical deliverables (D2.1, D2.2 and D2.3) and the lifestyle protocols suggested by clinical partners of the consortium. Finally, all the international guidelines regarding the development of applications for this specific target group were taken into account (as presented in D5.1).

The three clinical sections are, at M24, already integrated in the gamified environment and for this reason they are presented as a unique prototype, as it will be in the final version for end users. The three sections are strictly interdependent and are also dependent on the whole functioning of the gamified environment.

4. UPDATE OF GAME-BASED ACTIVE AGEING ENVIRONMENT

D5.2 (Game-based active ageing environment), according to the DOREMI Document of Work, was delivered in M14, when activities regarding the design and development of the gamified environment should have been closed. Nevertheless, as also explained in D5.2, according to the methodological approach that was chosen to design the game-based environment (User Centered Design) and according to the key role of the environment in WP5, the task couldn't be considered definitively closed in M14. For this reason, D5.2 presents the gamified prototype in a temporary version. After M14 user centered design activities went on, collecting feedback with users, at the same time of the feedback collection about the main areas of the application, in UK and in Italy, with different and updated versions of the prototype. For this methodological reason, the design of the game environment continued in parallel with T5.3, T5.4 and T5.5, until M24. Furthermore, to obtain a well-integrated and working application (both from a look&feel and a usability perspective), it was necessary to design and develop the environment at the same time of the three main areas of the application.

The final version of the game-based active ageing environment is presented and ready for a trial in the prototype delivered for D5.3, D5.4 and D5.5. However, in this document a brief walk-through of this final version is shown.

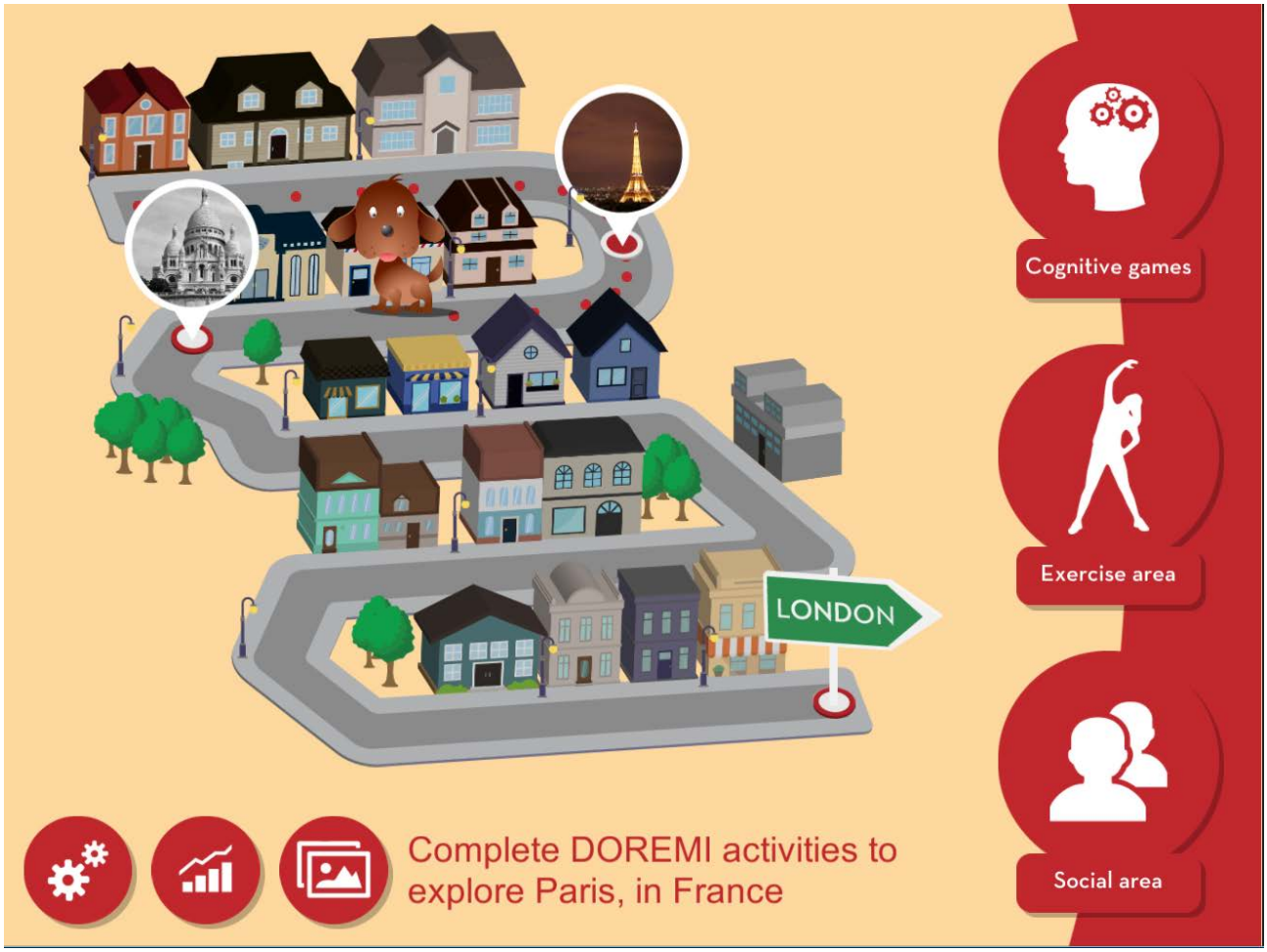

Figure 1 – The main page of the DOREMI game-based active ageing environment.

As designed for the first mock up, in the gamified environment each user has to walk the dog around a path, based upon aggregate scores from all 'clinical' areas and 'real' activities. Each path represents a European city. For each of these cities, there are five different milestones, used to engage the users and motivate them to continue their activities (based on the life style protocols). These milestones represent four different important monuments, famous in that city. The last milestone is represented by the sign of the next city that users can visit (London in Figure 1). Completing all the suggested activities (cognitive games, physical exercises, social interactions and nutritional diary), users can reach a milestone every day. Of course they can also need more time to reach milestones.

On the path, users can see only the next milestone (Sacre Coeur in Figure 1) in a black and white picture; all the milestones already reached (Eiffel Tower in Figure 1) in coloured pictures. All the unlocked achievements are collected and can be seen in a dedicate area, the 'Achievement section'.

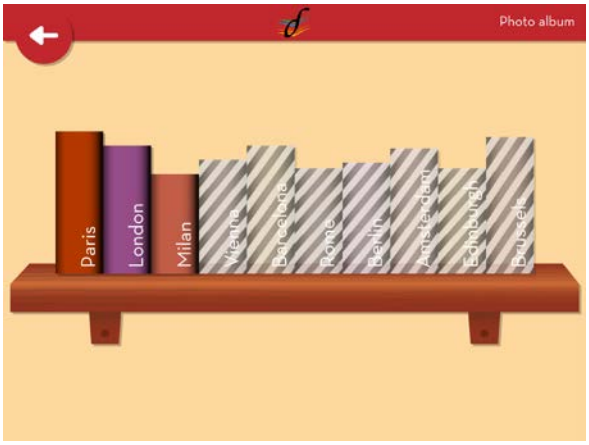

Figure 2 - The Achievement section

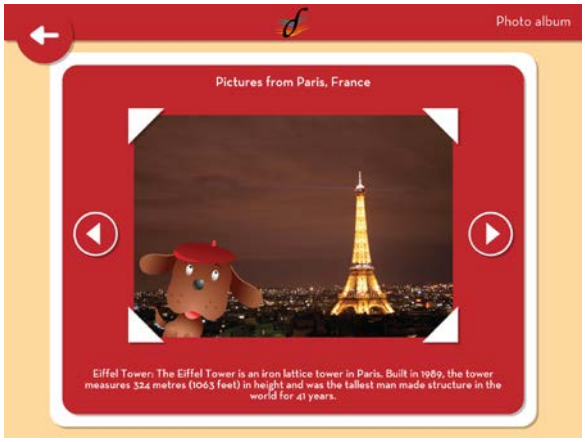

Figure 3 - An example of achievement: A picture from Paris in the photo album

In the achievement section, a photo album for each of the cities that can be 'virtually visited' through the DOREMI application is shown, distinguishing the already unlocked ones (Paris, London and Milan in Figure 2) and the locked ones. Touching each of the unlocked photo album users can open the book and see all the collected achievements (Figure 3), with a brief description of the monument.

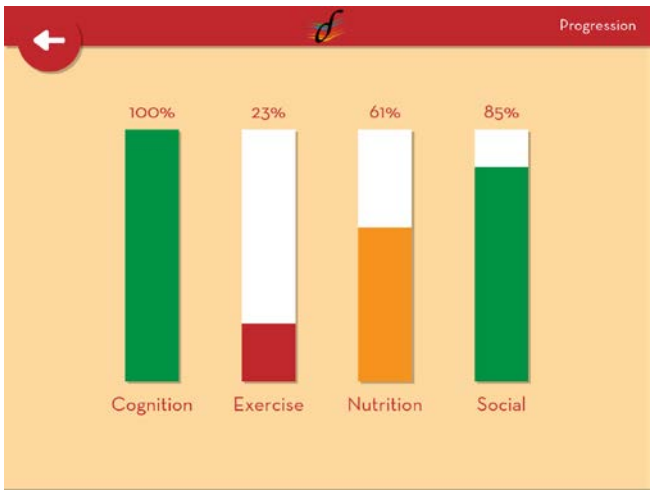

Figure 4 – The progression area

Furthermore, in the 'progress area' (Figure 4), users can see how close they are to reaching the next level and traveling to a new city. The bars represent their progress in cognition, exercise, nutrition and social activities. When all four bars reach 100% they will progress to the next level and be able to explore the next city. Each time they achieve a new level the bars will reset to 0%. In this way users can easily understand witch kind of activity they need to train more or, in other words, which kind of health behaviours they should increase.

After each day, all the data collected by the DOREMI application and all the other sensors used in the project are sent to the DOREMI server, where the reasoner merge everything and through specific calculation (implemented within WP4 activities) gives back to the application data that are used to move the dog along the path and update the progress area.

5. DESCRIPTION OF THE EXERCISE AREA

In this section the wireframes of the Exercise Area are presented. A wireframe is a design document, prepared before the development of the application and, for this reason, not always correspondent to the final version of the prototype. These wireframes present the connections between the different function or sub-sections of the different areas. The main aim of this representation of the Exercise Area is to present all the functionalities and the way everything works in the application.

Users can access the Exercise Area through the dedicated button in the gamified environment (see Figure 1). The whole Exercise Area is shown in the biggest picture with arrows (Figure 5). The other images (Figure 6, 7, 8) represent a more detailed view of it, where numbers indicate connections between different pages.

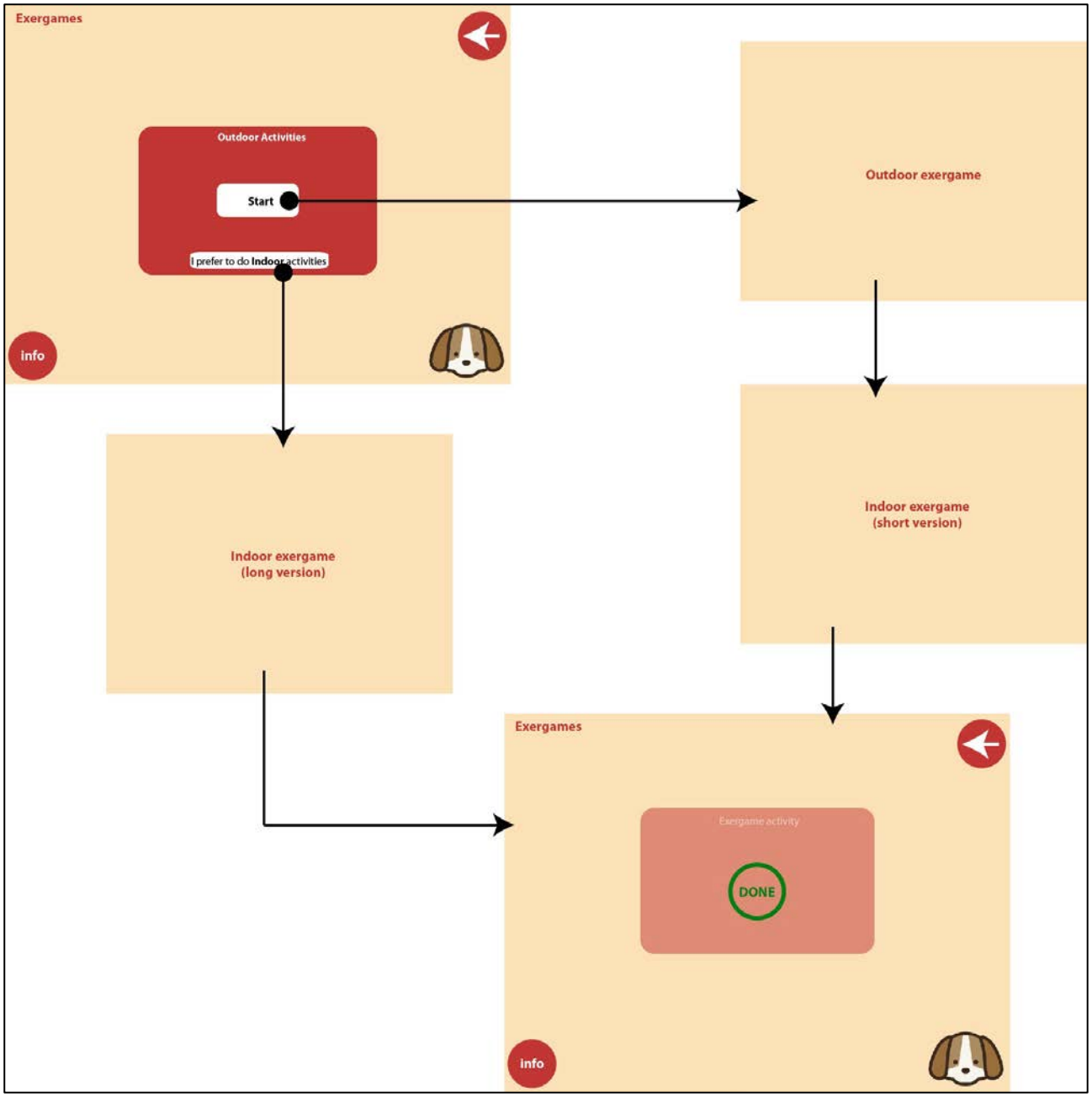

Figure 5 – The complete wireframe of the Exercise Area.

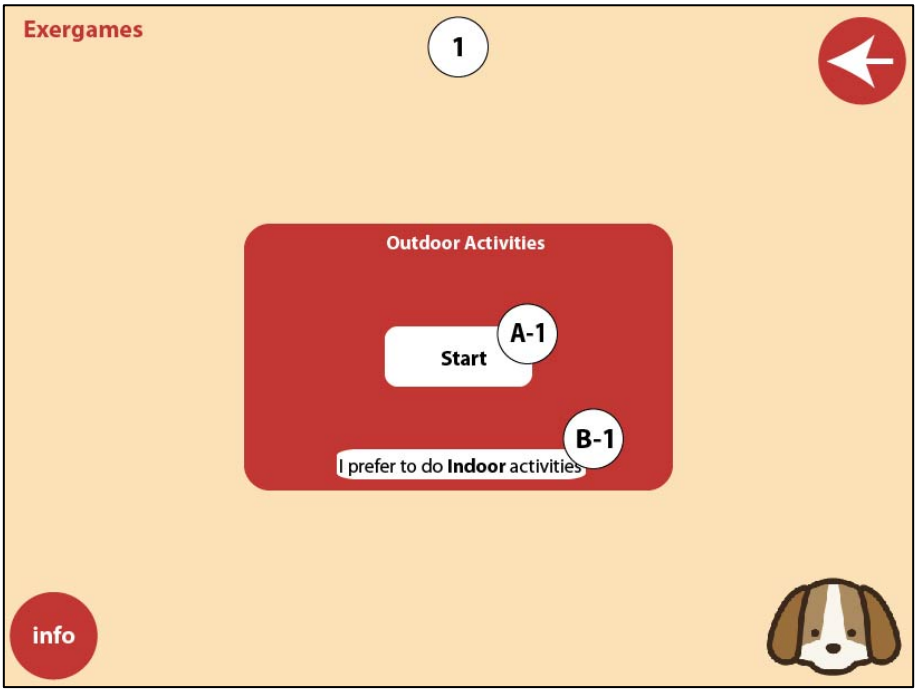

Figure 6 - The player can start the suggested activity of the day (in the picture: Outdoor), or change (in the picture: selecting indoor activities).

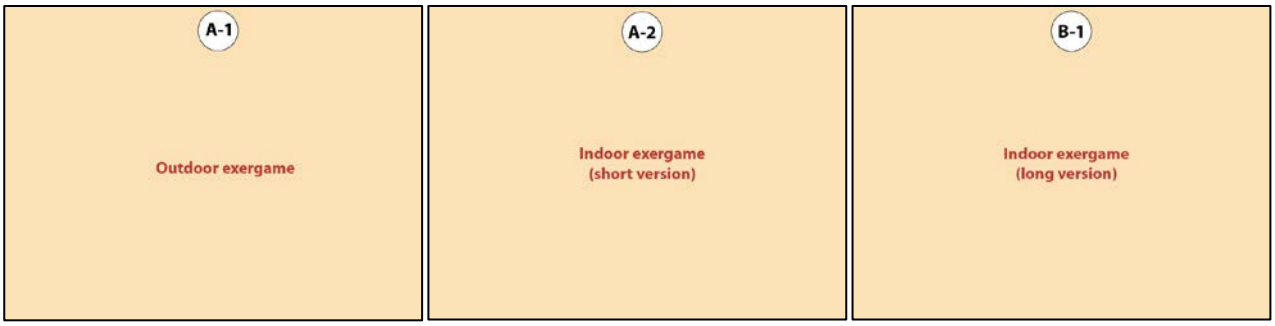

Figure 7 - The player completes the selected activity, outdoor (A-1) or indoor (B-1). After completing the outdoor activities, the player has to complete a reduced number of indoor activities (A-2).

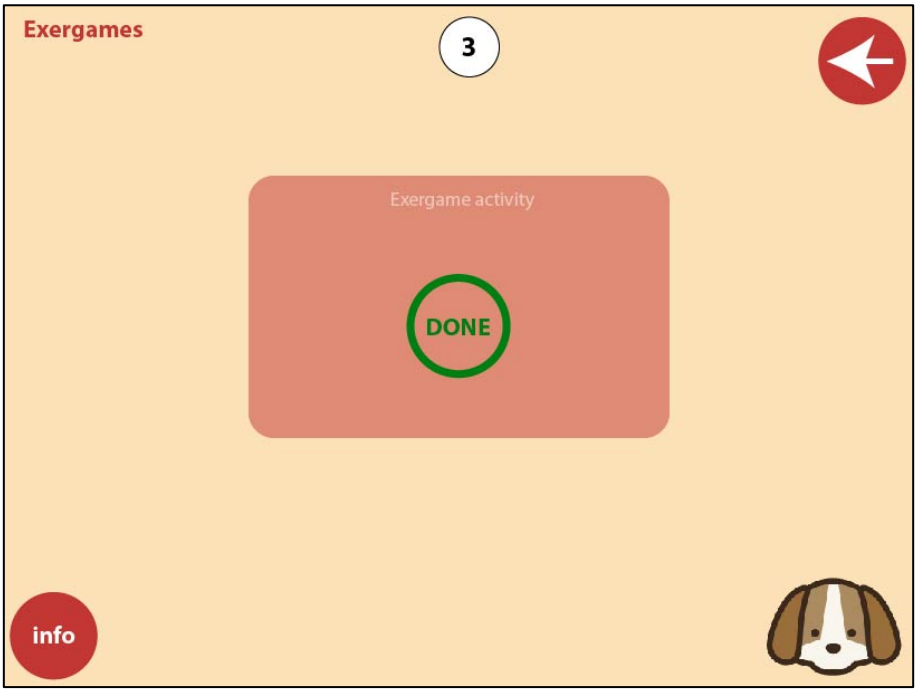

Figure 8 - After completing the activity, the menu will be updated.

Once users have accessed this area, they can decide with kind of physical activity complete in that day, indoor or outdoor. Even if, the system suggested every day one of these two based on clinical protocol. Nevertheless, it was decided to leave users free to select what they prefer, avoiding to reduce their motivation and their compliance giving them the feeling to be obliged to do something. After all, the main aim of this area of the application is to motivate users to complete some physical activity.

Selecting the indoor activity program, a playlist with different videos starts. Users should train alongside their exercise instructor across different phases and levels (better explained in paragraph 6, in this document).

The playlist structure is the same in each of the phases and levels: for each exercise, there is a 10-seconds preview, with an explanation of what users should do; then, there is a 20-seconds video, where users should complete the exercise, following the example of the instructor; then, again the 10-seconds preview and so on, till the end of the daily program.

Selecting the outdoor activity program, users are invited, first of all, to complete their daily walk. However, after their walk, they have to follow a brief version of the playlist exercises (as better explained in paragraph 6, in this document).

6. CLINICAL IMPLICATIONS

Physical activity (PA), health and quality of life are closely interconnected: the human body is designed to move and therefore needs regular PA in order to function optimally and avoid illness. Regular PA can increase general wellbeing, improve psychological and physical health, help to maintain self-sufficiency, and prevent specific metabolic disorders, such as type 2 diabetes, metabolic syndrome, and hypercholesterolemia. On the contrary, it has been observed in literature [1] [2] that a sedentary lifestyle is a risk factor for the development of many chronic illnesses. The psychological discomfort linked with aging can be modified or minimized by engaging in pleasant and shared PA. Sedentary people who become more physically active report feeling better from both a physical and a mental point of view, and enjoy a better quality of life. Based on the epidemiological studies carried out in Europe, it is evident that those who would highly benefit from regular physical activity (e.g., adults over 65 years of age) are generally the most sedentary [4]. For this purpose, the implementation of a European wide policy to improve active living and prevent physical and mental diseases is strongly needed. More specifically, methodologies and technologies which aim to make physical activity easier and promote personal responsibility in individuals aged over 65 years are warranted [3].
For adults aged over 65 years, the same goals as for healthy younger adults should be achieved with additional exercises like strength training and balance exercises to prevent falls. These are in addition to the routine daily activities (e.g., cleaning rooms, walking to go shopping, climbing stairs)[6]. PA, which causes a noticeable increase in heart rate, is beneficial for disease prevention. Some studies show that walking briskly for even one to two hours a week (15 to 20 minutes a day) starts to decrease the chances of having a heart attack or stroke, developing diabetes, or dying prematurely [7]. Walking is an ideal exercise for many people—it does not require any special equipment, can be done any time, any place, and is generally very safe. Several studies [8] [9] [10] [11] [12] [13] have demonstrated that this simple form of exercise substantially reduces the chances of developing heart disease, stroke, and diabetes in different populations.

To obtain significant effects of physical activity interventions in the elderly, the typical dose of physical activity prescribed is 20–60 min of aerobic activity three times a week. Since adherence to mobility enhancement recommendations by older subjects is generally low, it is important that participants undergoing training are followed-up by in-person interviews or use of mobility monitoring tools. Therefore, the DOREMI trial will monitor users' level of PA and mobility via the use of a bracelet and WSN. These systems, interacting with the DOREMI platform, can check and evaluate day by day the physical activity level of users.
Another important issue addressed by the DOREMI PA protocol will be the indoor activity, since the proportion of sedentary time is strongly related to metabolic risk, independent of physical activity. Older people may benefit from reducing total sedentary time and avoiding prolonged periods of inactivity by increasing the number of breaks during sedentary time. Therefore, an indoor PA program tailored to increase the number of breaks during sedentary time, as assessed by the accelerometer and WSN, was designed according to the individual habit of PA and sedentariness.
DOREMI PA protocol is also focused on outdoor activity. This element presents a double motivation: physical and psycho-social. Outdoor walking is considered relatively easy, feasible, and a popular action that can be performed by older adults to reach a good level of physical activity. For older adults walking can be a natural element of their daily routine, a demonstration of autonomy, and a cheap form of PA. Walking stimulates a global dynamism involving the whole body and it creates a connection between the upper and lower limbs in order to reach a

continuous postural equilibrium. Furthermore, walking can stimulate socialization: working in a group can be a psychological stimulus to improve physical status and give a feeling of safety against possible ailments.

5.1 DOREMI PA Protocol: concept

As general recommendations, the WHO 2010 Guidelines [14] will be followed in the DOREMI PA protocol.
For older adults the goal recommended by the WHO 2010 Guidelines is to achieve up to 30 minutes of mild-moderate intensity PA 5 days a week. The necessary dose of PA can be accumulated in bouts of at least 10 minutes and can also consist of a combination of mild-moderate intensity periods. Activities to increase muscular strength and endurance should be added 2 to 3 days per week.

The final protocol for PA for the older population presents 6 recommendations that are derived from the "Physical Activity Guidelines in the UK: Review and Recommendations" [15]:

1. Older adults who participate in any amount of PA gain some health benefits, including maintenance of good physical and cognitive function. Some PA is better than none, and more physical activity provides greater health benefits.
2. Older adults should aim to be active daily. Over a week, activity should add up to at least 150 minutes (2½ hours) of mild-moderate intensity activity in bouts of 10 minutes or more – one way to approach this is to do 30 minutes on at least 5 days a week.
3. For those who are already regularly active at moderate intensity (those without sedentariness impairment enrolled in the trial), comparable benefits can be achieved through 75 minutes of more vigorous intensity activity spread across the week or a combination of moderate and vigorous activity.
4. Older adults should also undertake PA to improve muscle strength on at least two days a week.
5. Older adults at risk of falls should incorporate PA to improve balance and co-ordination on at least two days a week. In particular, the BERG balance scale was selected and prescribed for a continuous evaluation during trial thanks to use of Wii balance board system integrated in DOREMI platform.
6. All older adults should minimize the amount of time spent being sedentary (sitting) for extended periods.

Moderate-intensity aerobic activity is any activity that causes a slight but noticeable increase in breathing and heart rate. One way to gauge moderate activity is with the "talk test"- exercising hard enough to break a sweat but not so hard that you cannot comfortably carry on a conversation. This simple rule will be taught to the participants to help them to self-monitor whether they are achieving the recommended level of PA intensity.

The DOREMI PA protocol will pursue the following physiological objectives:

- Respiratory system: reduction of oxygen demand and respiratory engagement during a certain movement
- Cardiovascular system: increase of maximum cardiac output, increase coronary blood flow, better utilization of peripheral oxygen by the working muscles
- Strength and flexibility: strength and gait increase, improvement of balance

The DOREMI PA Protocol, stimulating a regular physical activity, can:

- Increase overall physical well-being
- Improve physical and psychological health
- Help to maintain self-sufficiency
- Reduce the risk of developing diseases, such as, hypertension, ischemia, obesity, etc.
- Help to take under control some life conditions (e.g., stress) and pathologies
- Help to minimize consequences of disabilities and to manage chronic pain

Furthermore, it presents a series of physiological advantages:

- Respiratory system: reduction of oxygen request and pulmonary ventilation induced by physical effort
- Cardiovascular system: increase of cardiac output and coronary blood flow; better utilization of blood oxygen by body muscles
- Maximal oxygen consumption: this parameter (VO2max) diminishes from 25 to 65 years. Older adults thanks to physical activity and weight control can slow down this process
- Bone tissue: under physical effort, bones can increase their cellular density reducing the risk of fractures
- Force and flexibility: increase of body force, improvement of walk and equilibrium

DOREMI PA protocol is mainly based on two phases:

- First phase: build an active lifestyle
- Second phase: maintain the active lifestyle

The first phase is based on 6 elements:

1. Know the advantages of a regular physical activity
2. Regulate aerobic activities
3. Learn new activities or start again old ones
4. Learn articular mobility and stretching exercises
5. Learn to lift and move weights
6. Favour social activities involving other older adults and situations where it is possible to have diversified motor stimuli

The second phase is a natural evolution of the first one. In particular, when an active lifestyle is reached, this is based on:

1. 20-60 minutes of aerobic exercises (3 times each week, at least)
2. Exercises to improve force in lower and upper limbs and abdominal muscles (2 times each week, at least)
3. Daily exercises for balance and articular mobility
4. Frequent exercises and activities to stimulate motor control and learning

5.2 DOREMI PA Protocol: structure

DOREMI PA Protocol is organized in three phases with three different levels of engagement, as described in the table below. The first level is necessary to ensure the users reach the minimum guidelines for an active lifestyle. Levels 2 and 3 are focused on further increasing the level of

physical activity and ensuring its maintenance. The PA protocol incorporates both outdoor and indoor activities.

		LEVEL 1	LEVEL 2	LEVEL 3
OUTOOR	Walking	25’	35’	40’
	Articular mobility exercises and stretching	5’	5’	5’
	TOTAL TIME	30’	40’	45’
INDOOR	Articular mobility exercises	11’ 30”	11’ 30”	11’ 30”
	Strength exercises	10’	10’	15’
	Exercises using weights	5’	10’	10’
	Backbone unloading	5’	5’	5’
	CSST	30”	30”	30”
	TOTAL TIME	32’	37’	42’

Table 1 – DOREMI PA protocol: indoor and outdoor activities and levels

Each indoor and outdoor session has specific sections useful to support and improve physical activity in the elderly population:

- Articular mobility: is the capability of articulations to freely move covering totally their range of movements, without limits and pain. Articular mobility exercises help to preserve the functional autonomy and also prevent and control articular painful syndromes.

- Stretching: the contraction muscle capability is directly proportional to its capability to stretch: the more a muscle is able to extend itself, the more is able to contract and finally to develop force. By stimulating muscular and connective tissue flexibility, elasticity and movement capabilities are improved. Articulations are more resistant to degenerative diseases with a reduced incidence of calcifications.

- Muscular strengthening: this activity heavily involves muscular mass for a limited working time. Muscular force and resistance are fundamental for functional autonomy and to prevent falls.

- Backbone unloading: unloading of the lumbar spine by means of flexion/extension exercise can reduce pain and increase the perception of improved back strength.

- Chair sit to stand test (CSST): provides a quantification of lower limbs muscular force as well as giving information about the subject's capabilities to perform a series of daily actions, such as, climbing the stairs, getting in or out of a car, or getting in or out of a bath [16]. CSST is included in the Short Physical Performance Battery (SPPB) [17], the most utilized test to evaluate pre-frail condition and transition from pre-frailty to frailty in older people. CSST will complement the 21 PA exercises designed for DOREMI solution against sedentariness, and displayed in the exergame.

7. TECHNICAL ASPECTS

6.1 High level Game Server and Reasoning engine integration

A high level diagram of data flows between the Gamified Environment and the DOREMI backend (Game Server) has been designed. The diagram is general enough to support the plugging in of further games in all the three DOREMI sections (Cognitive Games, Exercise Area and Social Area).

Following the input from physicians and experts, the engineering team designed the overall structure illustrated in the picture below:

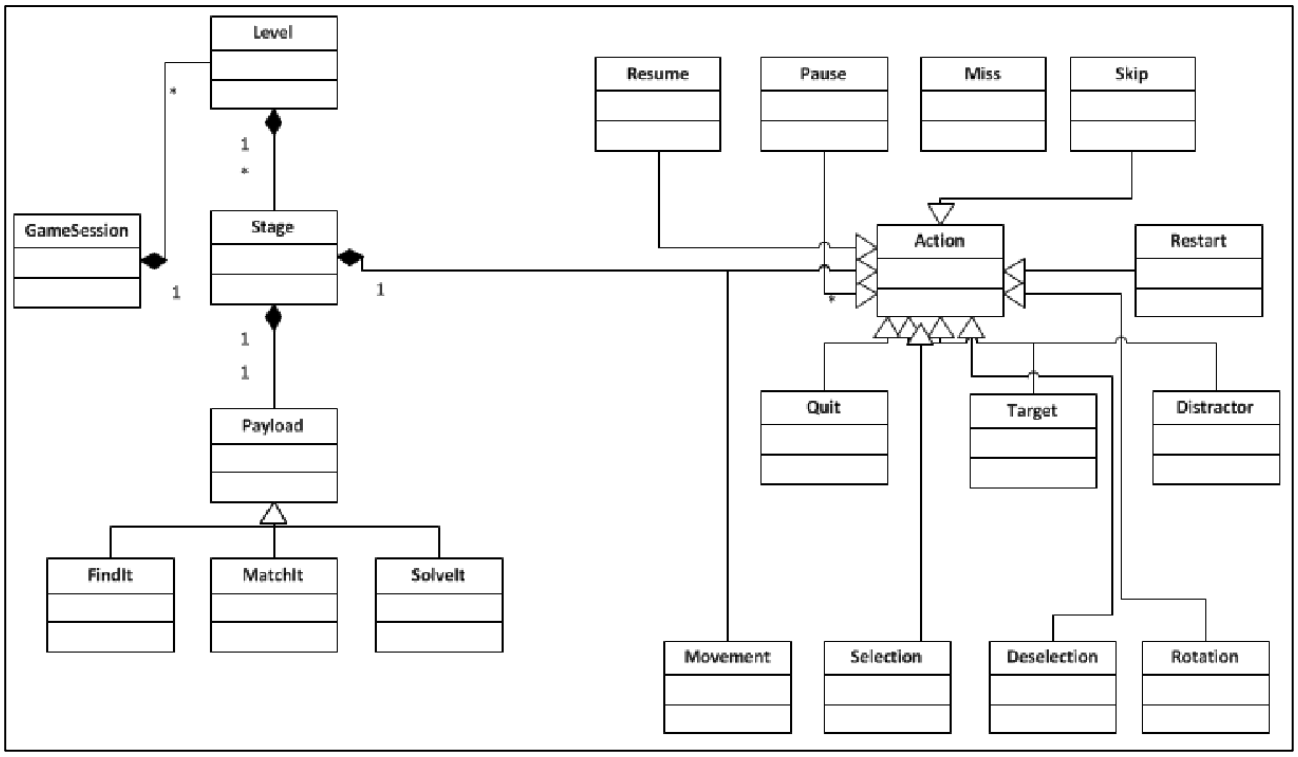

Figure 9 - Data structure

Each game has been analysed and the main entities involved for data representation identified. Every day a Game Session is started for each game required from the Patient records. Each Game Session consists of a set of levels and each level is composed by several stages. During each stage any action the user performs will be categorized and stored locally on the tablet. Once the user has completed one stage, data will be sent back to the Game Server, then the current status of the Gamified Environment and the reasoning engine KIOLA updated for further reasoning.

The data stream exchanged between Game Server and KIOLA is in JSON format and is called "*observation*". Observations are documented in AIT specifications which will be included in D4.2 and are sent to KIOLA from the Game Server using the KIOLA API described in the same document. For convenience some sample observations can be found in Appendix 1.

Every time a stage is completed the whole set of recorded user interactions will be sent to the game server and to KIOLA for storage and future reasoning. This kind of behaviour has been specifically designed in order to: minimize the data transfer exchange, and decrease bandwidth usage, battery drain of the tablet and latency in the user interaction of the game. On the other hand, sending a bulk set of information would involve a heavy load of data to be sent at a single time point, augmenting the risk of information getting lost, and the application crashing. As a

result, the user's performance data for that day could be lost. With the implemented approach, in case the application crashes or network disconnects, the user will be able to start again from the stage where he left.

6.2 Exercise Area structure

The exergames were developed using video exercise sessions shaped for the DOREMI target group. The android TTS engine has been used as spoken interface with the users.It was not possible to use a normal android API for the videos because at the beginning of the development it was not possible to directly embed the video in the application without going full screen, which resulted in part of the UI control and feedback from the App not being visible. It has been necessary to develop a proprietary controller to achieve the prototype version. Most probably in further Android versions, standard video streaming APIs will be available. Samples of the data flows for Exergames compliant with the general model are provided in table format, and below are listed some samples:

ACTION EXAMPLE		
VARIABLE	**TYPE**	**DESCRIPTION**
uid	guid	User id
timestamp	timestamp	Time when action is executed
action id	guid	Action id
stage ref (stage id)	ref	Stage id
type	categorical nominal	pause / resume / skip

Figure 10 – Instance of class Action

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9. APPENDIX

8.1 Appendix 1 - JSON Observations: data structure


```
{
  "observation":{
    "profile":"stage",
    "data":[
      {
        "profile":"progressive",
        "value":75
      },
      {
        "profile":"game_type",
        "value":"mdc_vnd_ait_game_types_match_it"
      },
      {
        "profile":"match_it",
        "data":[
          {
            "profile":"number_of_card_pairs",
            "value":23
          },
          {
            "profile":"number_of_semantically_related_pairs",
            "value":58
          },
          {
            "profile":"full_board_game_match_it",
            "value":"random_string"
          }
        ]
      },
      {
        "profile":"pause"
      },
      {
        "data":[
          {
            "profile":"position_miss",
            "value":"random_string"
          }
        ],
        "profile":"miss"
      },
      {
        "profile":"skip"
      },
      {
        "profile":"restart"
      },
      {
```

```
        "profile":"quit"
      },
      {
        "data":[
          {
            "profile":"position_target",
            "value":"random_string"
          },
          {
            "profile":"delta_target",
            "value":"random_string"
          }
        ],
        "profile":"target"
      },
      {
        "data":[
          {
            "profile":"position_distractor",
            "value":"random_string"
          },
          {
            "profile":"delta_distractor",
            "value":"random_string"
          }
        ],
        "profile":"distractor"
      },
      {
        "profile":"movement"
      },
      {
        "profile":"selection"
      },
      {
        "profile":"deselection"
      },
      {
        "profile":"rotation"
      }
    ]
  }
}
```


END OF DOCUMENT