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*Dissemination Level:
PU=Public
PP=Restricted to other program participants (including Commission Services)
RE=Restricted to a group specified by the consortium (including Commission Services).
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**Nature of Deliverables:
R=Report
P=Prototype
D=Demonstrator
O=Other

Abstract

Deliverable 5.1 “Gamified active ageing protocol” provides a theoretically driven foundation on which to build the gamified environment for DOREMI. Definitions of relevant games and gamification devices are described, along with examples of existing gamification tools used to increase participation in positive health behaviours. Psychological theory on motivation and engagement is introduced to highlight the importance of matching skills with ability when designing successful games and gamification devices. It is suggested that gamification devices to motivate participation in nutrition, sedentariness and cognition protocols will need to be designed by consulting both accessibility guidelines and older people. It is proposed that the user centred design activities conducted for DOREMI (focus groups and usability testing) will ensure that DOREMI games and gamification tools will be useful, relevant and user-friendly for the target participants. Finally, results from market research indicate that no product currently exists on the market which covers the areas of sedentariness, nutrition and cognitive function and is designed specifically for older users with mild cognitive impairment.

Keywords

Games; gamification; usability; active aging; cognition; nutrition; sedentariness; social interaction; accessibility.

LIST OF BENEFICIARIES

No.	Participant Organisation name	Short name	Country	Project Entry month	Project exit month
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1.2	IMA	Contribution to Chapter 6	01/09/2014
1.3	CNR	Suggested revisions to 6.3 and 8.2.1	13/09/2014
1.4	UOC	Contributions to Chapters 6, 7 and 8	17/09/2014
1.5	CNR-IFC	Final check, submission	30/09/2014

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2. ABBREVIATIONS

MMSE- Mini Mental State Examination
MoCA – Montreal Cognitive Assessment
MCI - Mild Cognitive Impairment

3. EXECUTIVE SUMMARY

Deliverable 5.1 is titled "Gamified active ageing protocol" and provides a detailed description of how DOREMI will gamify the active ageing protocols covering nutrition, sedentariness and cognition, in addition to outlining a plan for the development of cognitive training games later in WP5 and the gamification of exercise, nutrition and social interactions.

Deliverable 5.1 is structured in four sections. The first section discusses the theory behind games and gamification and their application to behaviour change interventions. Clear definitions of active ageing, games and gamification are provided. Additionally, this section covers a detailed discussion on how gamification techniques such as badges, leader boards and rewards systems can be applied to nutrition, sedentariness and cognition protocols in order to motivate participation in these health behaviours. The second section provides information on suitable user design considerations when creating games for older people with mild cognitive impairment, along with methodology for user-centred design activities. Later, proposed level systems for DOREMI activities are discussed. Following from this, the third section reports the results of market research and scientific literature review of cognitive training games. Additionally, successful gamification tools to promote positive nutrition, exercise and social behaviours are reported. The final section provides guidance on the practical application of gamification theory, market research and scientific evidence to the DOREMI active ageing protocols.

The aim of this deliverable is to provide a theoretically driven foundation on which to build the DOREMI gamified environment.

4. INTRODUCTION

By the year 2050, an estimated 35% of the European population will be aged over 60, with the largest increase in those over 75 (European Commission., 2014). As outlined in the DOREMI Description of Work, older people are at significant risk of poor quality of life, poor nutrition, sedentariness, cognitive decline and social isolation, which in turn poses a significant increase in age-related public spending on health and social care (European Commission, 2006). DOREMI involves delivering a lifestyle intervention using a tablet computer and non-invasive physiological monitoring, which could encourage autonomy in making better nutritional choices and increasing physical activity, social participation and cognitive function in older people. The rationale for DOREMI is twofold: first, assistive technology could be a cost effective model for supporting the needs of older people, offering increased independence whilst reducing burden on health and social care systems (Beech & Roberts, 2008). Second, digital games designers have shown that by harnessing games mechanics, behaviours can be 'gamified', encouraging increased engagement with exercise, diet and cognitive stimulation (Lumos Labs Inc., 2014; MyFitnessPal LLC., 2014; Nike, 2014; Zichermann & Cunningham, 2011). Ijsselsteijn, Nap, de Kort, & Poels, (2007) suggest that although digital games have the potential to enhance the quality of life of older users, there are significant design issues that need to be addressed when designing a games environment for an older target market. This report will discuss the application of psychological theory and games design techniques to the development of age and cognition-appropriate games and gamified activities for DOREMI.

Deliverable 5.1 is structured in four sections. The first section discusses the theory behind games and gamification and their application to behaviour change interventions. Clear definitions of active ageing, games and gamification are provided. Additionally, this section covers a detailed discussion on how gamification techniques such as badges, leader boards and rewards systems can be applied to nutrition, sedentariness and cognition protocols in order to motivate participation in these health behaviours. The second section provides information on suitable user design considerations when creating games for older people with mild cognitive impairment, along with methodology for user-centred design activities. Later, proposed level systems for DOREMI activities are discussed. Following from this, the third section reports the results of market research and scientific literature review of cognitive training games. Additionally, successful gamification tools to promote positive nutrition, exercise and social behaviours are reported. The final section provides guidance on the practical application of gamification theory, market research and scientific evidence to the DOREMI active ageing protocols.

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5. THEORIES OF GAMIFICATION AND GAME DESIGN

5.1 Definitions

5.1.1 Active ageing

According to the World Health Organisation, active ageing is defined as "the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age". In this definition, the term "active" does not just relate to being physically active, it relates to a less passive approach to ageing which allows older people to "realize their potential for physical, social, and mental well-being throughout the life course and to participate in society, while providing them with adequate protection, security and care when they need" (World Health Organization, 2002).

The DOREMI project is a lifestyle intervention which follows this active ageing framework, providing an effective therapy for older people by increasing physical, social and cognitive wellbeing, whilst, encouraging autonomy and independence. This report will discuss procedures which will be put in place to encourage engagement with the DOREMI system (using gamification and psychological theory), effectively train cognition, enable participation in social and physical activities and make informed choices about nutrition.

5.1.2. What is a game?

It is important at this stage to define the characteristics of games and gamification as the areas targeted by DOREMI will utilise elements of both types of activity. A game is defined by Roberts, Arth, & Bush, (1959) as a recreational activity characterized by:

1. organized play
2. competition
3. two or more sides
4. criteria for determining the winner
5. agreed-upon rules

In the field of computer game design, a similar definition is proposed "..a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome" (Salen & Zimmerman, 2004). Broadly, a computer game consists of participation in an activity which is has one or more players, rules, and a victory condition (Rogers, 2014). Characteristics of a game include:

- Genre

Genre in terms of computer games relates to the gameplay interactions of the game external to the story or theme. Some examples of computer game genres are first person shooter, puzzle games and sports games.

- Theme

The theme of a video game is the setting or scenario of the gameplay. For example, at a martial arts tournament or in outer space.

- Actions

Actions are the interactions the player makes with the game. This may be things such as opening chests, firing a weapon, or casting a spell.

- Progression

Progression marks how far along in the game a player is. This can be demonstrated through a number of devices. It could be an increase in level of the character, progression along an over-arching story, or an increase in difficulty.

- Rules

The rules of a game define the constraints a player must keep within. Some game rules may be that a player can only equip one weapon at a time, or that a player may move one space per movement point given.

- Game mechanics

The most basic building block of a game; a rule or description that covers a specific, single aspect of play. For example, pressing a sequence of buttons to make a character jump is a simple mechanic, defeating an enemy on-screen when it is struck by a fireball is a mechanic, collecting coloured bubbles for points is a mechanic. (Menard, 2012)

5.1.3 What is a serious game?

A serious game is a computer game designed with a primary purpose other than just entertainment. Michael & Chen, (2005) provide the following definition, "A serious game is a game in which education (in its various forms) is the primary goal, rather than entertainment". An example of this is a driving simulator, used to practice driving ability. The aim of the game would be to improve driving skills in a safe, virtual environment order to enhance real world driving ability. Serious games are a method of delivering health messages or health benefits in an enjoyable and engaging way. For example, "Sickle Cell Terminator" (Folajimi, Istance, & Rolfe, 2012) which was designed to provide an engaging platform to educate children in Nigeria about sickle cell disease and encourage self-care management.

Dr Kawashima's Brain Training series (Nintendo, 2006) is a clear example of a serious game in the genre of brain training (see Figure 1). The user engages with an interface to complete a series of puzzle-type exercises with the goal of achieving points for performance. The appealing interface and in-game achievements are designed to motivate the user (engagement). By performing an element of the game successfully, they will receive points (a quantifiable outcome). If the user does not perform an activity correctly, they will not receive points or be able to progress to the next level (rules). A similar strategy will be utilised in DOREMI to train cognitive functioning using a series of cognitive training games.

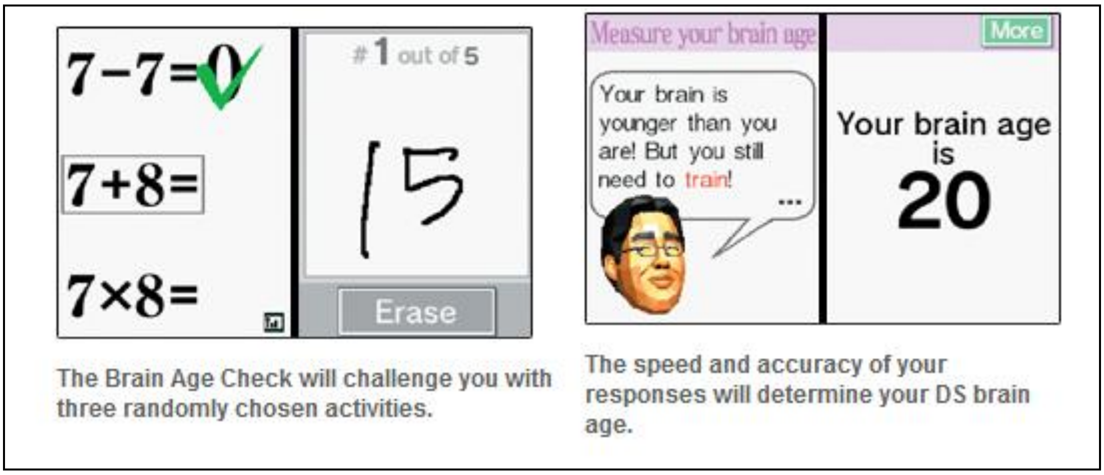

Figure 1. An example from Dr Kawashima's Brain Training: How old is your brain?

5.1.4 What is gamification?

More recently, health behaviours have been targeted using a different strategy known as gamification; Gamification, described as "using game design elements in non-game contexts to motivate and increase user activity and retention" (Deterding, Dixon, Khaled, & Nacke, 2011), and games are not synonymous terms, although they do share similar characteristics. Gamification involves designing a set of games-related activities and game mechanics to achieve a "serious" or real world objective. The application of game elements in non-game contexts can make every day activities more enjoyable and engaging, which has the potential for impacting public health initiatives. Gamification has been successfully utilised to significantly improve dietary choices and increase fruit and vegetable consumption in an American school (Jones, Madden, Wengreen, Aguilar, & Desjardins, 2014). Furthermore, a recent initiative by the Russian government's Olympic Change Campaign (www.olympicchange.ru) used gamification techniques to increase exercise participation in the general public in advance of the Sochi Winter Olympics. Travellers on the metro were encouraged to increase their physical activity by completing 30 squats in front of a modified ticket machine. On completion of the exercise, a free metro ticket was dispensed. The novelty of the scenario provided the engagement, and the free metro ticket provided motivation, feedback and most importantly, a reward.

Gamification is a relatively new term, coined in 2003 (Pelling, 2014) but the gamification process of rewarding or punishing behaviour in order to influence future behaviour is rooted in the psychological theory of operant conditioning. Operant conditioning refers to a learning process in which behaviour can be influenced by a system of rewards and punishments (Skinner, 1938). To influence behaviour in DOREMI, a gamification system of rewards will be utilised to provide positive reinforcement when active ageing protocols (e.g. exercise participation) are followed. The gamification techniques outlined below are examples of how a reward system can be utilised to promote exercise activities, cognitive training participation, social engagement and healthy food choices in DOREMI.

5.1.4.1 Points

Points are a simple but effective gamification technique. They provide a quantifiable outcome for the behaviour completed and the achievement of points can be a motivating reward. The Nike+ Running application (Nike, 2014) encourages users to monitor real-world running activity with the GPS system on a smartphone. The application conceptualises points as Nike Fuel which is earned as activity is completed. In Figure 2 below, a run of 10km has accrued 2120 Nike Fuel points (see bottom right). The points accrued in this app feed in to a leader board (see section below), although points do not always feed in to leader boards in gamification (e.g. if the gamified activity is not designed to be competitive).

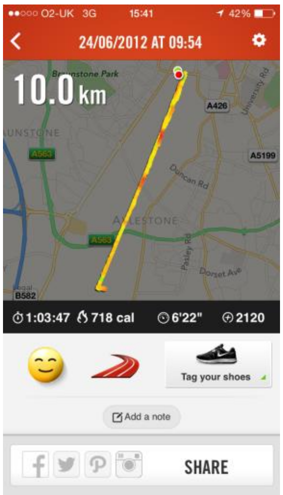

Figure 2. Example of Nike Running application showing Nike Fuel points accrued as exercise is completed

5.1.4.2 Leader boards

Leader boards can be utilised as motivational tools for users and are effective for both individual and team competing. In a further example of gamification from Nike+, Figure 3 shows how people can propose challenges for competing (in this case, the last person to accumulate 100 miles of running will buy the other users a meal) which are visually demonstrated as a leader board. Leader boards can help foster a sense of camaraderie and community among users.

Figure 3. Example of a leaderboard challenge on Nike+

5.1.4.3 Badges

Badges are an incentive to engagement which are awarded for actions the user has just completed. They are usually based on a number of accumulated points. Badges are similar to points but can offer a more visual display of achievement. The app Foursquare (Foursquare Labs, 2014) encourages people to 'check in' when they are at particular landmarks or businesses. The badge in Figure 4 was awarded for attending the gym 10 times in 30 days. Badges can be displayed on the homepage of a user.

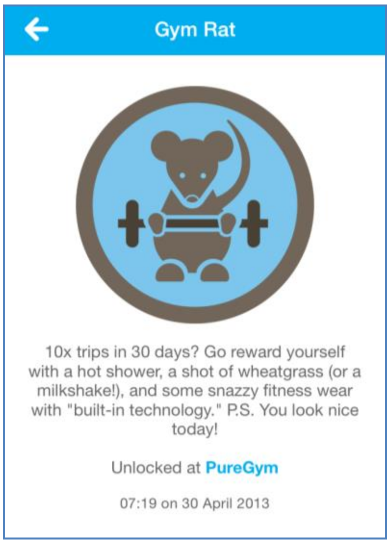

Figure 4. Example of a badge reward for gym attendance on Four Square

5.1.4.4 Progress monitoring

Progress monitoring allows users to see how the smaller actions undertaken by an individual (e.g. 15 minutes walking) can relate to a larger accomplishment (10% of a 150 minutes activity per week goal is met). A simple progress bar can be motivating, but progress can be visually represented in a number of ways. In 2014, a series of 30 day exercise challenges have been posted and shared on online forums (Facebook, Reddit etc.) which can easily be gamified in a smartphone application so that people can digitally monitor their progress. The images from the 30 Day Ab Challenge application (Jozic Productions, 2014) in Figure 5 below show that ticking off a series of abdominal exercises for that day results in visual progression in a progress bar and tick chart. Daily progress, "Sarah has completed Day 11 of the 30 day ab challenge!" can be posted on social forums for support and encouragement.

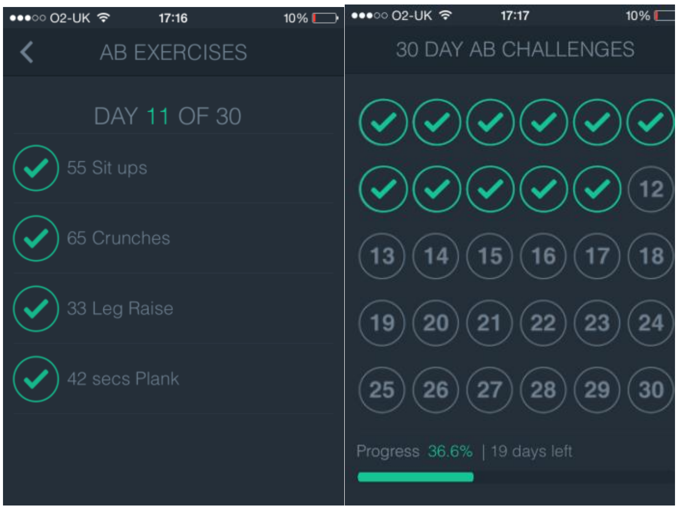

Figure 5. An example of gamified progress monitoring for a 30 day exercise routine.

5.1.4.5 Feedback

Immediate feedback upon completing an action is motivating and can increase the user's self-efficacy, a person's belief in ability to successfully complete a task (Bandura, 1977). Feedback can take many forms. In the examples from the Joggle brain training application (Joggle Research, 2014) shown in Figure 6, users receive immediate feedback in terms of a score on the cognitive task (28 points for speed in the game), a medal for a new high score with an encouraging message, “Keep it up!”, and an achievement badge. In the initial stages of engaging with a gamified interface, feedback should be more frequent and rewards easier to achieve. As users become familiar with the rules of the gamified task, feedback will change and rewards will become harder to achieve.

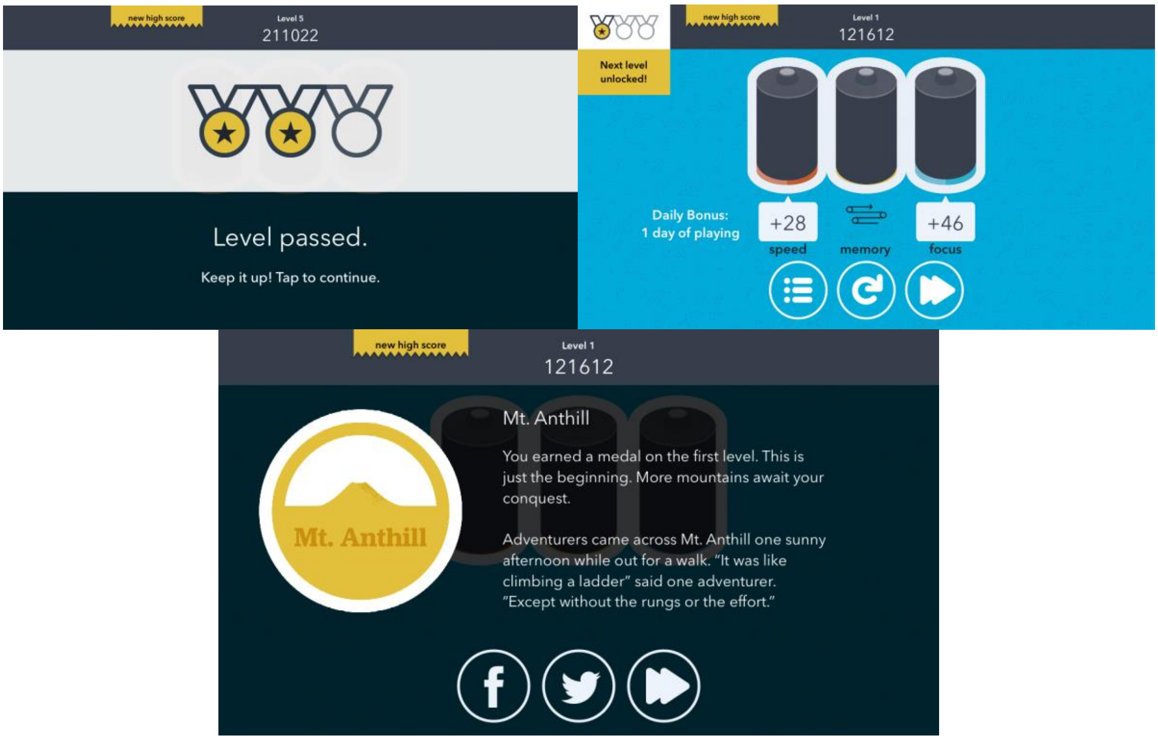

Figure 6. Example of various gamified feedback devices in the Joggle cognitive training application

5.2 Motivation in gamification

Motivation underlies the concept of gamification (Deterding, 2012; Wu, 2011). If DOREMI participants are not motivated to engage with the health protocols for social engagement, nutrition, exercise and social participation, they may not experience the full benefit for the system, or withdraw from the study. It is also important to address participants’ motivations to engage with the technology used in DOREMI, as unfamiliarity and/or feelings of incompetence could be a barrier to participation. For increased engagement in the DOREMI gamified health protocols, users must be intrinsically motivated to participate in the gamified actions. Intrinsic motivation refers to a desire to perform a given behaviour or activity, not to meet a human drive (such as the need for food or sex) but purely for the joy of doing it. This differs from extrinsic motivation, which refers to our drive to complete an activity in order to achieve a reward (e.g. points, badges or feedback). An example of intrinsically motivated behaviour would be the hours that humans dedicate to hobbies such as painting, reading or playing computer games, despite participation not resulting in a tangible reward. Deci & Ryan (1985) argue that intrinsic motivation is based on the human need to be competent and make choices without external influence (self-determination); this explains why a person keeps playing the same difficult level of a computer game over and over until they succeed, or why a gambler will continue putting coins in a slot machine until she wins. Intrinsic and extrinsic motivators are not rigidly separate entities. Deci & Ryan (1985) further argue that these motivators are fluid, and that by offering extrinsic rewards for completed behaviours (e.g. a reward) which are meaningful and pleasurable, we can satisfy the intrinsic human need for competence and self- determination, and in turn, people will adopt the extrinsically motivated behaviour as though it were intrinsic. In other words, people can start completing a behaviour that was not initially interesting or inspiring because it is fun, not just because they are being rewarded.

Very often, humans are not intrinsically motivated to complete health-related behaviours. Within the field of Human-Computer Interaction, vignettes are often used to provide a holistic view of system use. In the following vignette we explore the motivations of a hypothetical DOREMI participant:

Robert is a75 year old retired teacher and is overweight. He regularly eats more than his recommended calorie intake and does not exercise. Robert lives in residential housing where he has access to a gym and healthy food options. Despite being educated about weight control, and having the choice and facilities to eat well and take exercise, Robert is not intrinsically motivated to complete these behaviours. Choosing a balanced meal over a pizza does not come naturally to him and he does not find exercise rewarding. Gamification can be used to offer extrinsic rewards to Robert, such as receiving points for completing the DOREMI exercise plan and advancing up a weight loss leader board past his friends in the residential home and other people using DOREMI internationally. Receiving these extrinsic rewards feed Robert's intrinsic human drive to be successful and competent when completing activities. Robert may be more motivated to receive 10 points on a leaderboard than lose 5kg in weight so it is important that extrinsic rewards are chosen appropriately to provide a meaningful experience. Extrinsically motivated behaviours are more likely to become intrinsically motivated behaviours if the motivation is meaningful, pleasurable and consistent with the person's world view (Deci & Ryan, 1985)*. If the gamification of this behaviour is effective, and the extrinsic reward strong enough, Robert's participation in good nutrition and exercise behaviours will start to become intrinsically motivated (e.g. completed just for fun), and can create long term systemic change.*

Humans like to feel in control, for this reason it is not advised to simply offer extrinsic rewards when gamifying health behaviours, as it can diminish our internal drive to complete an activity (Deci, Koestner, & Ryan, 1999; Nicholson, 2012). It is recommended that the game based activities in DOREMI need to be meaningful, pleasurable and relevant for the target users, in order for the active ageing protocols to be adopted in the long term. Later in this document, we will discuss user-centred design activities which aim to elicit ways to design games and apply gamification appropriately for the DOREMI target population.

5.3 Flow theory- matching challenge with abilities for optimal enjoyment of DOREMI activities

If the balance between challenge and current abilities is 'just right' when completing a DOREMI activity, a state of total immersion in the task and optimal intrinsic motivation can be achieved. This state of immersion is called Flow (Csikszentmihalyi, 1990) and is demonstrated in Figure 7 below. If the user is not challenged enough by a task to match their abilities, they may become bored and withdraw from the activity. Similarly, if the task is too difficult for their current ability, the user may become anxious and withdraw. To encourage Flow, it is recommended that the difficulty level of DOREMI activities is carefully designed, so that a balance between skills and challenge is achieved. For example, as users complete the DOREMI cognitive training games and their abilities increase, the challenge should increase accordingly (the difficulty level of the game will be increased). It is also essential to take the particular cognitive needs of a person with mild cognitive impairment into account. Particular needs of older people with MCI will be discussed in Section 6. Flow is not just applicable to the cognitive games in DOREMI; the gamified exercise, nutrition and social activities should also promote the state of Flow in participants by matching individuals' abilities with an appropriate level of challenge.

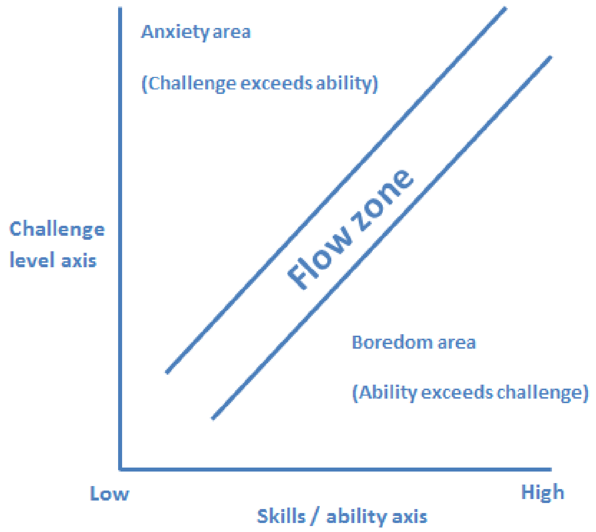

Figure 7. Theory of Flow. Adapted from Csikzenmihalyi (1990)

5.4 How often should gamification 'rewards' be offered?

Deci, Koestner, & Ryan, (1999) report that rewards and positive reinforcement can enhance intrinsic motivation via operant conditioning, but only if the rewards are unexpected. Different schedules of reinforcement have been shown to produce different behavioural patterns in animal and human studies (Ferster & Skinner, 1957). When learning a new behaviour, fixed interval reinforcement schedules are most effective, helping to build up a conditioned behaviour. In a fixed reinforcement schedule, the user learns quickly that they will receive a fixed reward after completing an action, for example receiving a drink (reinforcement) after putting a coin in a vending machine. However, this schedule of reinforcement is not robust in that the user is unlikely to continue the behaviour of putting coins in the vending machine if they do not receive the reinforcement (if the drink does not come out). Maintenance of behaviour can be encouraged by offering an intermittent reinforcement schedule. Using slot machines as an example, the behaviour of putting the coin in the slot machine is sometimes reinforced with a financial reward (reinforcement) but mostly it is not. When an intermittent reward schedule is used, the user will continue the behavioural response of putting the coin in the slot many more times in the hope of receiving a reward (Kazdin, 2012). In other words, rewards at fixed intervals are less successful motivators in the long term than sporadic reward systems (if somebody gets a reward of the same size, each time they complete an action, it becomes less engaging).

5.4.1 Gamified reward schedules- conclusion

Gamification theory is largely based on behavioural psychology models of operant conditioning and schedules of reinforcement. When designing a gamified environment, Zichermann & Cunningham, (2011) suggest offering variable ratio, variable schedule reinforcement as well as fixed rewards, meaning that rewards should occur at different intervals and offer varied levels of reinforcement. For example, users completing a daily food diary could always be given 10 points on completion of the diary (fixed reward) but they could also receive an unexpected booster reward e.g., a badge for making the most dietary changes out of all other participants or an extra 50 points for completing a full week of the food diary.

5.5 Self-efficacy

The theory of Flow indicates that the level of challenge in a DOREMI activity should be matched by the level of ability of the user before they can enjoy an activity. In addition to matching the level and content of games to participants' ability, the design of the gamified environment will need to take in to account that DOREMI participants may have limited experience with the technology which the DOREMI gamified environment will be delivered on. To succeed in engaging participants to perform the active ageing protocols, it will be necessary to enhance their self-belief in completing the DOREMI activities. Successful gamification uses the tools outlined in section 5.1.4 to allow users to believe in their competence for completing a behaviour. This self-belief in ability to perform a behaviour is called self-efficacy (Bandura, 1977). People who have high self-efficacy towards a behaviour are more motivated to complete that behaviour than those with low self-efficacy. Furthermore, health choices such as such a physical exercise and nutrition have been shown to be dependent on self-efficacy (Conner & Norman, 2005). Following the guidelines of (Bandura, 1977), behaviour modification will be promoted by considering the four components of self-efficacy; mastery experience, vicarious experience, persuasion and physiological arousal. The application of self-efficacy theory to the DOREMI system will be promoted in participants during the training phase and intervention in the following ways:

- **Mastery experience** (mastery is experienced on completion of part of a task and being successful). During the training phase for the DOREMI intervention, participants will initially be trained by staff in the residential homes to complete a simplified version of the games and gamification activities. An early success when completing a new activity will build self-esteem and feelings of competence. It is advised that whenever a new game or activity is introduced in DOREMI, a simple training activity for that task with no possibility of failure should first be conducted. Throughout the intervention, encouraging visual and auditory feedback should be provided by the system, not just when a task has been completed successfully but also to provide motivation for participant's who have not met a goal or completed the activity correctly. For example, visual feedback could be text on the screen which says "*you almost did it, try again*" or "*don't worry if you can't finish this task, let's move on to something else*".

- **Vicarious experience** (observing other people completing the task successfully). During the training phase for the DOREMI intervention, participants will be trained on aspects of the games and activities and will observe others completing the tasks successfully, which will encourage their belief in themselves to complete the tasks; "*If they can do it, maybe I can do it too*". Ideally, members of the reference group (used for the user-centred design activities) who are the same age as the intervention activities will be involved at this stage (e.g. intervention participants attend a workshop with other older person trained in the activities).

- **Persuasion** (being encouraged to complete the task). Verbal encouragement for taking part in the task will begin at the recruitment stage for the DOREMI intervention. Studies suggest that older people can have computer anxiety and negative feeling towards the effort required to learn a new technology (Marquié, Jourdan-Boddaert, & Huet, 2002). It is important that people are reassured from the offset that the technology used in DOREMI will not be too complicated for them. For this reason, appropriate terminology will be explored during the user-centred design activities. For example, are older people put off by the term 'computer game? What could motivate older people to engage with the DOREMI system? During the training phase of the intervention, DOREMI users will receive positive reinforcement in the form of verbal persuasion from the trainer about the benefits of completing the DOREMI activities. N.B. Although users will be persuaded about the benefits of engaging with DOREMI health protocols, verbal persuasion does not involve DOREMI participants being pressured or coerced by the trainer to take part in DOREMI activities against their will.

Additionally, the DOREMI gamified environment should be designed to be persuasive and encouraging and motivational persuasion could provide 'rewards'. Potential mechanisms include a motivational message on starting the games and on load screens. As previously reported, Zichermann & Cunningham, (2011) suggest offering variable ratio, variable schedule reinforcement, meaning that persuasive messages should occur at different intervals and offer varied levels of reinforcement. This could be related to success in completing the activity and/or reinforcement about the positive outcomes gained from completing the activity.

- **Physiological arousal** (a person's appraisal of their physiological state). Personal self-efficacy is also judged by our perception of our own physiological state in particular situations. Emotional arousal states resulting from stress and anxiety can affect self-efficacy expectations towards a task (Conger & Kanugo, 1988). In other words, people are more likely to feel competent if they are not experiencing strong adverse arousal. This factor is particularly important for DOREMI because it is known that older people can find engaging with technology anxiety-inducing (Marquié, Jourdan-Boddaert, & Huet, 2002). Users may be avoidant of DOREMI activities because they anticipate that the situation may make them anxious, or that they will be unable to cope with the activities. During the user-centred design activities with older people, we will explore personal barriers to the active ageing protocols and the use of the DOREMI system. The DOREMI system can then be designed accordingly, to minimise user stress and anxiety in our target population. The trainer(s) should be equipped to provide adequate support to participants, and it is proposed that a weekly 'drop in' session for DOREMI users and a support telephone number should be available at each site to deal with any problems. An appropriate mastery experience (see above) during the training phase which allows the user to explore the technology under supervision can help to minimise any anxiety towards the DOREMI system (Ijsselsteijn, Nap, de Kort, & Poels, 2007).

5.6 Is gamification effective?

The vignette presented in Section 5.1.5 illustrates that the primary purpose of gamification is to bring about some kind of behavioural change. Here the desired behaviour is to lose weight, where initially the intrinsic motivation to do so is lacking in the person concerned. This intrinsic motivation may arise from extrinsic motivation gained by the person improving their position on a weight-loss leader board. Hamari, Koivisto, & Sarsa, (2014) deconstruct gamification into 3 linked concepts. Motivational affordances (the leader board) lead to favourable or positive psychological outcomes (increased intrinsic motivation). These in turn lead to positive intended behaviour changes (weight loss), assuming of course that gamification is successful.

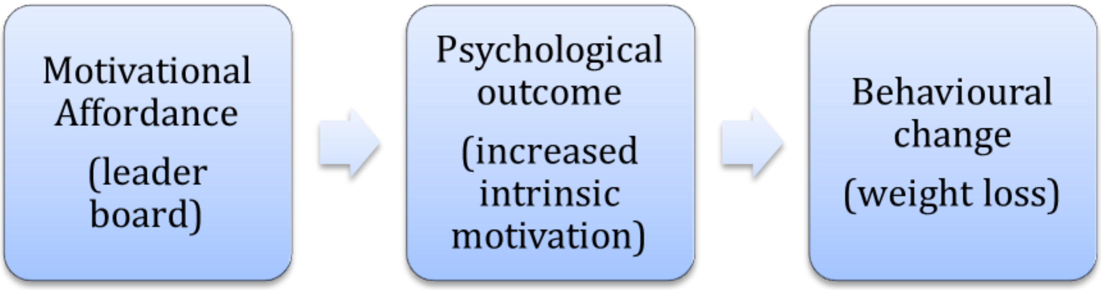

Figure 8. Stages of Successful Gamification (Hamrari Koivisto and Sarsa, 2014)

They analysed 24 studies that had evaluated the success or otherwise of gamification applied in different contexts. In some of these only psychological outcomes of gamification had been assessed (by interview or questionnaire), in others it was only the behavioural outcomes, and in some it was both. They report that most of the studies reviewed reported positive results for some of the motivational affordances that had been introduced. Generally therefore, they concluded that gamification was effective. However, this may have been short term in some cases due to a novelty effect.

In the sections above, we have summarised how successful gamification and games design will match a person's skills and abilities, promote self-efficacy and effectively exploit motivations to promote engagement with active ageing protocols. To date, there is limited research on the use of meaningful gamification in older people. Recently, Koivisto & Hamari, (2014) looked at the effects of age and gender on perceived benefits, enjoyment and ease of use (amongst other variables) of a gamified exercise service (Fitocracy). In a sample of adults aged 19-59, perceived benefits and enjoyment of gamification were not affected by age, however perceived ease of use of gamification declined as age increased. These results suggest that although gamification tools are enjoyed equally across the age span of the sample, they are not perceived by older people as being user-friendly. To the best of our knowledge, there is no published research conducted in this area on people aged 60+, however we can draw on the growing body of games design literature for older people when designing user-friendly gamification tools in DOREMI (Barlet & Spohn, 2012; Bouchard, Imbeault, Bouzouane, & Menelas, 2012; Ellis et al., 2013; Fua, Gupta, Pautler, & Farber, 2013; Jones & van der Eerden, 2008). In line with the recommendations of Ijsselsteijn, Nap, de Kort, & Poels, (2007), to explore the needs and motivations of older users, substantial research effort will be employed, including focus groups, surveys and market research. In the sections to follow, we will discuss the needs of older people, and the methodology for user-centred design activities in Work Package 5. The user centred design activities will comprise focus groups will identify the optimal characteristics of a gamified environment for the uptake of the active ageing protocols proposed in DOREMI.

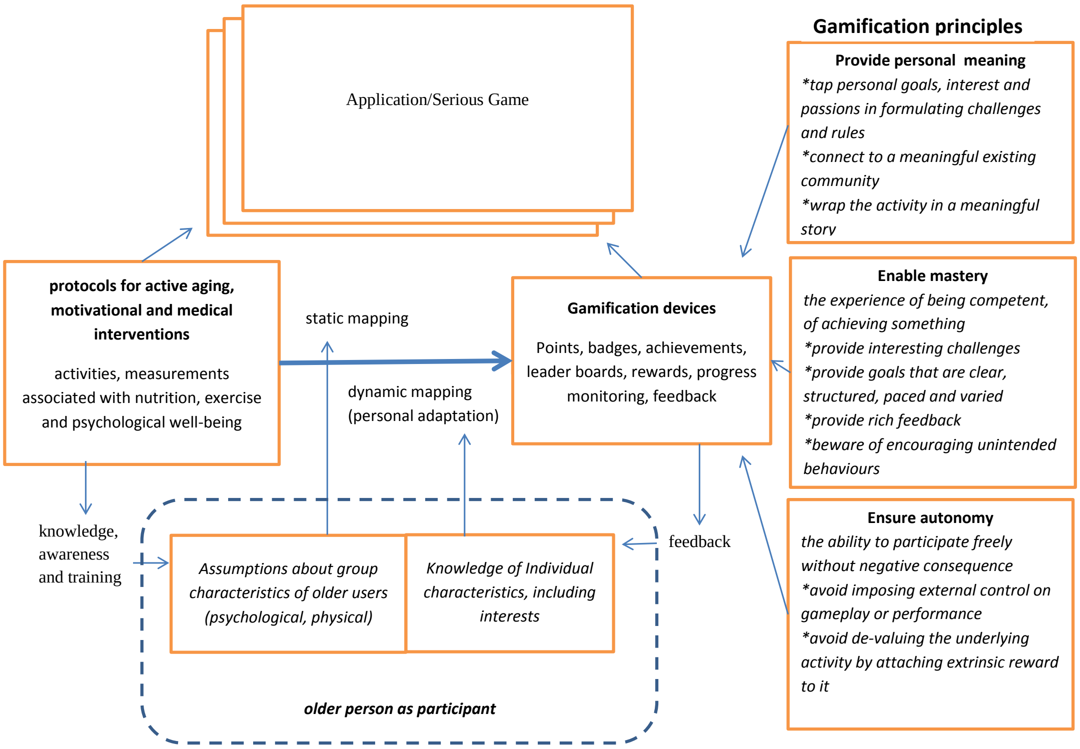

Figure 9. Process diagram for the design of gamification appropriate for a specific target group

5.7 Towards a process of designing effective gamification of active ageing protocols

The diagram above shows the main elements in the design of gamification of active ageing protocols in the context of the DOREMI project. The actual protocols will be discussed later. However, at the stage we can consider a decomposition of the protocols into a series of regular activities, possibly daily or weekly. These activities are candidates for association with gamification devices, or motivational affordances (Hamari, Koivisto, & Sarsa, 2014). The selection of the most appropriate devices will depend on assumptions made about the user group, shown in the diagram as *a static mapping* between activities and devices. There is a set of guidelines based on the characteristics of this user group that will steer this mapping. These are described in the next section and govern the choice of candidate gamification devices.

Adaptation of these devices to the individual participant depends partly on their own interests and intrinsic motivators, and partly on their own performance and progress. This is represented as a *dynamic mapping*.

The design of the application containing the gamification devices needs to adhere to principles or heuristics for successful gamification. Three of these have been identified (Deterding, 2011) which are outlined below:

provide personal meaning: tap into personal interests and goals (intrinsic motivators);connect to an existing community of people with similar interests (or build one for the purpose of the project); devise a meaningful story to contain the gamification devices.

enable mastery: this is closely related to the principles for self-efficacy described earlier. The person should be presented with challenges that are interesting for them, and goals that are clear. The choice of goals and progression between them should enable a state of Flow to be maintained.

ensure autonomy: this is the ability to participate freely without negative consequence. There should be no external sanction imposed against an individual for failing to achieve within the gamified system. Care must also be taken to guard against devaluing the underlying activity by attaching an external reward to it, for example, a person engaging in social interaction with others with the sole purpose of obtaining a reward or achievement, e.g. *"I don't really want to get to know you, but I want points towards my next New Friends badge"*.

5.8 Action points

- Games should be designed to be meaningful, relevant and pleasurable for the DOREMI target audience to maximise intrinsic motivation.
- Chosen gamification tools should be meaningful, relevant and pleasurable for the DOREMI target audience to induce intrinsic motivation.
- Games and gamification should be designed to maximise intrinsic motivation, using increasing challenges, pitched at an appropriate level for DOREMI target users in order to create a state of Flow.
- Rewards (e.g. points, badges, encouragement) should be varied, some occurring on a fixed basis, others offering variable ratio, variable schedule reinforcement.
- DOREMI intervention participants should be adequately trained in the use of the DOREMI system in order to maximise self-efficacy for DOREMI activities and subsequent engagement with the DOREMI intervention.

6. DESIGN OF USER PROFILE MODULE

6.1 User-centred design

User-centred design has been the mainstay of human-computer interaction since its emergence as a distinct discipline at the end of the 1970s. The common view then of the failing of interactive systems was that their design was primarily functionality driven, rather than driven by the needs of those who will use the system. A 'user-centred' design process emerged as a means of designing computer systems to fit (usually) a work-related situation for which computer support was needed. This was essentially grounded in an analysis of 'users', 'tasks' and 'environment'. In today's very different world of personal mobile devices connected via the internet, the same basic principles still apply. Applications now support a far wider range of human activities than ever before. A gamified exercise recording app still has to be built around the needs of the group of people who will use it. It has to support the tasks associated with different types of exercise, and the design has to be suited to the particular environment in which it will be used.

The analysis of user characteristics is intended to make explicit for the design team the set of assumptions about the user population that would influence the choice of particular design alternatives when creating the interaction between user and system, and the way in which this interaction is presented at the interface. The kinds of user characteristics referred to here are:

demographics: age range, educational background, gender.

frequency of use: how often a person will use the system and the extent to which learning how to use the system can be assumed to take place.

discretion to use the system: whether or not system use will be discontinued if user motivation or system usability is poor.

knowledge of the task which the system will support: the extent of the domain knowledge that the user can be expected to have when using the system.

knowledge of how to use computers or tablets: familiarity with generic conventions, such as file storage, or interaction techniques.

experience of other similar systems: can the user be expected to have used other systems with a similar purpose (such as exercise apps), and can their familiarity with those can be exploited in the design of the new system.

physical characteristics (limited abilities, say in literacy, memory, vision): how will the design deliberately take these into account

cultural characteristics: differences between users in different European countries, for example the UK and Italy, in attitudes towards levels of on-screen help and guidance and the way in which system is introduced to users

attitudes towards computers: will the user group have particular positive or negative attitudes towards using computers in general

existing skills (keyboard, touch-screen, smart phone use): does the user group have particular skills that could be exploited, or lack particular skills, that could influence the choice of input device, for example.

Analysis of user group characteristics is an early stage in a user-centred design process (who the user is). Capturing what the user will do with the system (what the user does) is another early stage and is a critical part of mainstream systems design methodologies. Where the system is being designed to support work, then a *task analysis* of the job the user will do is undertaken in order to provide a detailed basis of the information required to be displayed by the system, the decisions required and the information to be communicated to the system for each task. In addition to formal methods that seek to decompose work or a collection of activities into series of tasks, more holistic methods exist for capturing user activity. *Scenario-based design* methods (Rosson & Carroll, 2003) seek to capture a set of requirements in a 'story' that describes a typical instance of system use. The vignette in section 5.2 that describes Robert, the retired teacher, is an example of a scenario. Design scenarios typically emphasise activities that are carried out together at a particular time. A collection of scenarios then forms a foundation for the designer to understand what the system needs to do. These ideas have been incorporated into contemporary approaches to systems design in the form of *use cases* (Rational Unified Process) and *user stories* (Agile development).

Environmental characteristics refer to the physical, organisational and social environments in which the system will be used. Capturing these will make explicit the physical location (indoors or outdoors, range of outdoors temperatures envisaged). If using the system outdoors in cold weather is envisaged, can it be used with gloves, for example? The organisational environment will make explicit the level of technical support and maintenance that can be expected. The social environment will make explicit the amount of peer support (and pressure) that can be expected.

User-centred design is often utilised when developing health technologies and involves the input of target-users throughout the development process to ensure that the outcome technology is easy to operate and has value to the intended users (De Vito Dabbs et al., 2009). User centred design is an iterative process, involving a multi-disciplinary team and incorporating key stakeholders throughout the process of game development (Profitt & Lange, 2012). Using an approach with heavy involvement of the target users is particularly important when designing for atypical game users and people with specific needs. The user-centred design approach has been successfully applied in the design of games for rehabilitation and education, (e.g. Lange et al., 2011) including an exercise game for older people (Profitt & Lange, 2012).

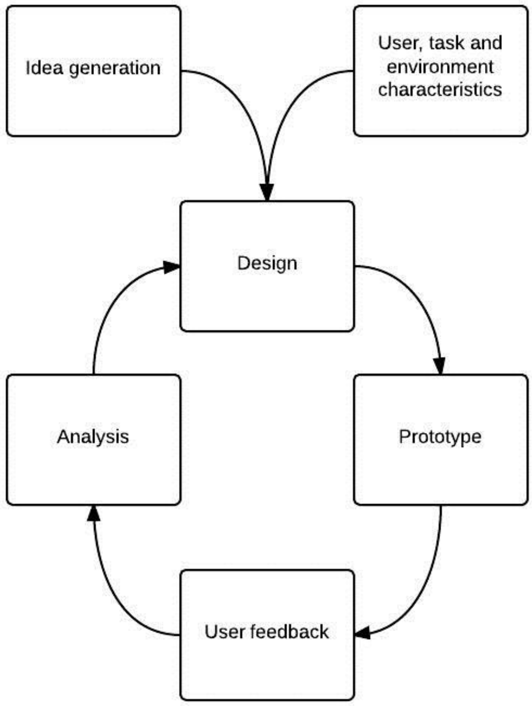

Figure 10. The User Centred Design Process. Adapted from Profitt & Lange (2012)

6.2 Translating user characteristics into design guidance

As previously discussed, the process of gamifying the activities associated with the active ageing protocols will be mediated by assumptions made of the characteristics of the user group. The design of applications and serious games to be undertaken in the rest of WP5 will also be based on assumptions made about the limitations and the capabilities of the group. In broad terms, the group members are older adults (65 -80 years old) with measured mild cognitive impairment, and either deficiencies in the amount of physical activity they usually take or deficiencies in their diet. The details of the inclusion and the exclusion criteria are given in D2.2

Literacy and numeracy levels vary with age and over the age of the DOREMI user group. In the English Longitudinal Study of Ageing (ELSA), participants were assigned to one of 3 literacy groups (low, medium and high). Three quarters of the participants in their 50s were in the 'high' group, but this proportion had fallen to less than half for participants in their 80s. Also while 12% of participants in their 60s were in the 'low' literacy group, this proportion had risen to 27%, more than double, for participants in their 80s. Proficiency in numeracy varied with age and also with gender. Older participants performed less well on the numeracy tests than did younger participants. Female participants performed less well than male participants (Jenkins, Ackerman, Frumkin, Salter, & Vorhaus, 2011). What is not clear at this stage is how much homogeneity there is with regards to similar levels of cognitive impairment in terms of literacy and numeracy. Nevertheless, reduced literacy and numeracy within the user group (compared with the adult population as a whole) will be a significant factor to consider in selection of gamification devices and in the design of serious games. For example, a numerical points system may be less easily interpreted than a progress chart.

It can be expected the DOREMI user group will differ from the adult population as a whole with respect to many of the user characteristics identified earlier in this section, not just literacy and numeracy. Indeed, having reduced cognitive capacity is a pre-requisite for inclusion in the user group. Consequently, a set of design guidelines is needed that covers a range of cognitive, sensory, motor and practical factors when designing games and gamified activities for the target population that the user group represents.

6.2.1 Summary of accessibility design guidelines for designing games for an older population

The guidelines outlined below have been informed by published games accessibility guidelines for older people and people with cognitive impairment. It should be emphasised that these guidelines are a starting point for successful design. Compliance with these will not guarantee that a particular game will be understandable or playable by all members of the user group. Collectively, they represent a translation of characteristics of older people with mild cognitive impairment into specific design guidance.

Table 1. Table of user requirements

Auditory
Adjustable sounds and music Music in games is designed to tap into emotions and affect mood to make gameplay more enjoyable. If not chosen appropriately music can act as an irritant and distraction to the main task. Auditory sensitivity can change with age and it is common to have some high frequency sensitivity loss. Therefore there should be some thought on whether music or other sounds should be used for DOREMI. If sounds are used then they should be audible for the participant and not a distraction to the game. [1]
Ensure distinct sounds are used for different events/stimuli Distinct sounds for different stimuli is useful for all players, but can also be an extremely helpful reinforcement when it is difficult to distinguish things by other means. [1]
Use lower frequency tones For non-speech audio signals, lower frequency tones (500-1000Hz range) are easier for older users to hear than higher pitched sounds. [3]
Visual
Give a clear indication that interactive elements are interactive Players with cognitive or vision impairments can have difficulty distinguishing which user interface elements or in-game items are intended to be interactive, and are sometimes not familiar with the same metaphors and conventions as other players. This can be achieved by clear and consistent differences in style, contrast, or additional signifiers such as a 'glow' or icon [1]
Ensure no essential information (especially instructions) is conveyed by text alone. Reinforce with visuals and/or speech. People may be intimidated by a block of text or find it hard to process. If the instructions for the game are that the user should 'press the red dot' there should be a visual image of the gameplay. [1]
Use an easily readable default font size.

Adjustable font size is another option but could be difficult to implement and adds another layer of complexity. It is also important to ensure regular well -spaced paragraph breaks. [1]
Use simple clear language. Text should not be over simplified, but length or complexity should be avoided if it is not required by the tone or to get the point across. [1]
Use simple clear text formatting. For clarity, fonts should have distinct letter shapes and prominent ascenders and descenders and be presented on a plain background. Text should be mixed case rather than all caps, unjustified left alignment, 1.5x line spacing, and around 70 characters per line for optimal legibility. [1]
The dynamics of game objects should be intuitive and easy to understand. Older users may find it easier to manage a game which involves fitting two tessellating shapes together (e.g. Tetris) than visualising the projectile trajectory of an object (e.g. Angry Birds). [2]
Provide high contrast between text and background Low contrast is a common complaint, particularly amongst older gamers. There are several common vision impairments that specifically result in a loss of contrast sensitivity. [1]
Clearly define contrasts and improve depth perception. Older people may have difficulties discerning the limits and borders of objects on a surface, and depth perception is reduced. Game objects should be thickly outlined. [5]
Use warm and bright colours for game objects Older people find it easier to process bright warm colours such as red, orange and yellow. Ageing reduces the ability to process blues, purples, dark colours and pastels, so these colours should be avoided. [6]
Use simple textures for all game objects Age related acuity deficits can cause images to appear blurred and details in textures difficult to discriminate. [5]
Communication
Use symbol based chat e.g. smiley faces For the social game- allowing symbol based chat makes communication easier and could even enable international communication between DOREMI participants in the UK and Italy. Emoticons e.g. smiley face can be used to facilitate this. [1]
Simplify any speech recognition technology

Base speech recognition on individual words from a small vocabulary (e.g. 'yes' 'no' 'open') instead of long phrases or multi-syllable words. This will simplify a potentially challenging new technology interaction for participants. [1]

Memory

In game events should be independent of prior events

Impaired episodic memory means a reduced ability to encode and recall new information. In gaming, this could mean problems relating a current game event to previous game events. For example, if a player was required to remember that another game character was behaving in a certain way towards the player's avatar due to an unfavourable event that happened last time the game was played. If the previous events were not encoded, they will not be associated with current events in game play. It is recommended that in-game events are structured to be as independent as possible. [2]

Ensure consistency of input methods

Ensure that all areas of the user interface can be accessed using the same input method as the gameplay (e.g. voice control should not be used on menu if the game cannot be voice controlled). [1]

Indicate / allow reminder of current objectives during gameplay

A reminder can help greatly, either permanently displayed, on player request, or triggered automatically by for example spending a long time without making and progress towards an objective. [1]

Indicate / allow reminder of controls during gameplay

Being able to access reminders through the user interface can help users with impaired memory greatly, and not only for the basic controls themselves – providing summaries of any game-specific mechanics or actions covered in tutorials to be accessed at a later date is also beneficial. [1]

Minimise the complexity of in game items or modifiers

It may be hard for people with semantic memory problems to learn and retain information about 'modifiers' (in-game items which are capable of affecting scores), like a health potion which can restore the players energy. If modifiers are used their appearance should be consistent and simple in order to make the item-effect relationship more obvious and easier to learn. E.g. health potions are always red and are the only red potions in the game. [2]

Avoid categorisation (unless reminders are frequent)

People with impaired semantic memory may struggle to collect items fitting in to a particular category e.g. collecting tools, a portable shelter and clothing for a 'wilderness survival kit'. [2]

Make rewards/punishments easily distinguishable

A decline in semantic memory could impair an individual's ability to associate specific actions with resulting rewards or punishments. It is suggested that consistent in-game rewards/punishment schedules are followed E.g. 5 points are always rewarded immediately after remembering 5 symbols in a memory game. It is recommended that rewards and punishments be easily distinguishable and obvious, for

example audible cheers on successful completion of a goal. [2]
Include contextual in-game help/guidance/tips Gradually introducing concepts to the player during gameplay also avoids overburdening gamers who are unable to process complex systems/concepts with too much information at once, and is more useful than upfront instruction/tutorial screens for people with short term memory issues. If possible allow users to repeatedly practice new tasks until they decide they are familiar and comfortable enough to proceed. [1]
Include interactive tutorials If the above is not possible, the best alternative is to include interactive tutorials. The combination of interaction with instruction gives more means of making an association and remembering, and practising the interaction in the context of gameplay is less demanding on short term memory than having to recall the instruction at the point in the future where the interaction takes place. [1]
Avoid multiple control processes per action Ensure controls are as simple as possible, or provide a simpler alternative. People with memory deficits may not remember a series of complex controls or actions. [1]
Use a quick start menu Allow the game to be started without the need to navigate through multiple levels of menus. People with short term or procedural memory impairments may struggle if having to make a number of selections (e.g. customising player type of game scenario) each time before starting the game. [2]
Provide in game prompts of game objective Player should not be expected to remember information (e.g. a tutorial) on a previous page prior to start of game. For example, if the objective of the game has been explained in detail on the previous screen, a brief reminder of the objective should appear on the game screen. E.g. “Tap the red dot”. [3]
Intuitive menus Intuitive menus provide the ability to quickly assess where certain options are without being frustrating. Menu items should be clearly positioned and all options should be no more than 2 levels deep. [4]
Reminder of current game objectives Players with working memory deficits may find it difficult to recall current information which is relevant to the task, e.g. current game objectives. Games should have real-time information presented immediately after each action. Scores could be presented via a pop up feed rather than displaying an aggregate score at the end of a round. A real time reminder of rewards strengthens the link between actions and effects. [2]
Don’t rely on players’ memory for future events Players should not be expected to remember to complete an action at a point in the future as they may have prospective memory deficits. The game should provide cues to remind them to complete such an action. The system should be designed to remind people to play the game, as well as reminding them of

in-game required actions. [2]
Allow all game narrative and instructions to be replayed. Short or long term memory issues or can make it difficult to remember where you are in a narrative, or situational impairments such as simply having had a bit of time pass since last time you played the game. [1]
Employ a simple, clear narrative structure Complex twisting narratives can easily lose or confuse anyone, but particularly gamers who have difficulty with memory or with understanding complex concepts. [1]
If using a long overarching narrative, provide summaries of progress Remembering what has happened to date in a narrative is difficult for people who have impaired short or long term memory. Providing summaries on loading screens or when starting a game can an effective way around this. [1]
Processing speed, reaction time and motor function
Allow players to progress through text prompts at their own pace Instead of a timer, the player should have to complete an action (e.g. press a text box which says "I have read this, let's move on") to remove the text prompt. If that's not possible, allow text prompts to be replayed or paused. [1]
User interface menus should not scroll. Scrolling interface menus can be difficult for people with slow reaction time and should be avoided. [1]
Avoid repeated inputs Quick time events that require a fast succession of repeated button presses can be difficult for people with speed and accuracy problems and should be avoided. [1]
Avoid simultaneous controls Ensure that multiple simultaneous actions (e.g. click/drag or swipe) are not required. Tapping is more simple and intuitive. [1]
Ensure interactive elements / virtual controls are large and well-spaced. This particularly applies on small or touch screens. A minimum of 2.4cm target area for interactive elements is recommended. [1]
Include a cool-down period (post acceptance delay) of 0.5 seconds between inputs. Older people may have motor problems in addition to being unfamiliar with the responsiveness of the technology. This could result in unintentional multiple button presses. It is recommended that there is a delay where no further input is recognised for 0.5 seconds after a successful button press. [1]

Provide stationary menu options Make interactive elements that require accuracy (e.g. cursor/touch controlled menu options) stationary. [1]
Simplify actions Ensure that all key actions can be carried out by digital controls (pad / keys / presses), with more complex input (e.g. analogue, speech, gesture) included only as supplementary / alternative input methods. [1]
References [1] Ellis et al., (2013); [2] Ijsellsteijn, Nap, de Kort & Poels, (2007). [3] Fua, Gupta, Paulter & Farber (2013) [4] Barlet & Spohn, (2012); [5] Bouchard, Imbeault, Bouzouane & Menelas, 2012; [6] Jones & van der Eerden (2008).

Table 2. Game device practicalities

Game device practicalities
Configuration of tablet The tablet should be configured to only allow access to DOREMI relevant activities to avoid confusion with other applications (and study contamination).
Equipment care Participants should be advised on how to appropriately look after the equipment provided. E.g. to avoid water, direct heat etc.
Instruction manual Participant should be provided with an easy access booklet with reminders on how to switch on the tablet, how to charge it and how to open the DOREMI application.
Battery life The tablet and phone should provide battery life reminders in good time for participants to charge them up (25% charge remaining, and every 5% decrement after that). Data will be lost if equipment is not charged.
Tablet positioning An appropriate stand or mounting device should be provided if the tablet will be used to deliver exercise guidance. Following exercise guidance whilst looking down will make the activity difficulty follow and could pose a health risk.
Include a means of practising without failure Practising during gameplay means that the likelihood of failure is high. Offering an option where it is impossible to fail allows people to practice at their own pace, provides a mastery experience and improves self-efficacy. [1]

References

[1] Ellis et al., (2013)

6.3 Adjusting difficulty in games

In this section we will discuss potential methods of adjusting the difficulty level in games. This discussion is mostly applicable to the cognitive training games in DOREMI. Later, in sections 6.3.4, 6.3.5 and 6.3.6 potential level systems for gamified exercise, nutrition and social DOREMI activities are presented.

6.3.1 Definitions

6.3.1.1 Scores

Scores in computer games are abstract quantities relating to a participant's performance. In many games, the score itself is the dynamic target needed to achieve a higher ranking or to win the game. Scores are typically used as a quantitative indicator of success and can typically be raised or lowered by the user's actions in game. Trying to beat a previous own score or that of other players adds to the replay ability of games. The score itself can be represented in different ways; either through things such as experience points, levels, in-game money, or as points on a leader board. Target scores in games can also be used to unlock extras in games such as new characters, tile sets, gear/outfits, extra lives, and collectibles. In puzzle games, scores are typically representative of the speed and efficiency of the solution the player provides.

6.3.1.2 Targets

Targets in computer games are set by developers to guide players to complete certain actions. Typically this method is used to teach players fundamental game mechanics to enable them to progress. In some casual games, targets are used to clear levels. Examples of this would be to achieve a set score to be able to progress to the next level. In games where progression is based on reaching a target score there tend to be multiple target scores to achieve to gain different ratings for the level. For example 10,000 points for 1 star, 20,000 for 2 stars, 30,000 for 3 stars.

6.3.1.3 Balance

Balance has several meanings in computer games. Where the player has multiple options for playable types, characters, classes, etc., it refers to ensuring that no one choice is drastically better than any of the others. With regards to puzzle and cognitive games, balance is more likely to refer to the level of skill required to complete a task at some point in the game

6.3.1.4 Levels

Levels are used as milestones to mark progression through the game as the player's skill increases. Different aspects of the game can have separate level systems associated with them. The main uses of levels are character levels, player levels, difficulty levels, story levels.

Character levels

In certain genres of computer games, like the turn-based strategy role-playing game Fire Emblem (Nintendo, Intelligent Systems, 2003) players may control multiple characters or units. Each of these may have their own rates of progression. In games such as Fire Emblem, individual characters can gain experience points to increase their personal level. An increase in a characters level typically increases attributes specific to the character and typically unlocks better equipment, skills, and abilities.

Player levels

In games where the player plays as the protagonist such as the action role-playing game The Elder Scrolls (Bethesda Game Studios, 1994) the player directly gains experience points to increase the characters level. Player levels typically allow the player to choose which attributes and skills they wish to have, allowing for more individual control. Player levels are also used as a status symbol in multiplayer games. In games such as Call of Duty (ActiVision, 2014), player levels are used to unlock more advanced equipment.

Difficulty levels

Difficulty levels in computer games are usually added in towards the end of development. Many games offer the player a choice of difficulty according to what they perceive their level of ability to be. Difficulty levels in games can be used to weight gameplay, such as modifiers on enemy health and damage output.

Story levels

Story levels, also known as chapters in certain games, mark advancements in the plot of the game. In classic video games, such as Sonic the Hedgehog (Sega, 1991), these were represented as zones. The progression of story levels is typically tied in with the level of difficulty and gives players an intrinsic reason to keep playing.

6.3.1.5 Level system

Level systems are typically designed around the genre of the game. In the case of role playing games levels are designed around the characters progression and mark improvements in ability. In this type of levelling system, earlier levels tend to be relatively easy to achieve so that new players can progress quickly into more complex aspects of the game.

In non-role playing games, such as puzzle games, levels tend to mark an increase in complexity of the puzzles. Typically in puzzle games each level will only be one puzzle. In strategy games levels are typically defined as the level of efficiency required to achieve objectives, usually confined by the amount of time before some negative action takes place.

6.3.2 Difficulty

Difficulty is the measure of user proficiency required to complete a task. The harder the task, the greater the level of difficulty, and the greater the level of user proficiency required to complete it. In regards to cognitive training in DOREMI the level of difficulty could be measured by the expected performance of the user based upon the degree of cognitive impairment. In this manner cognitive training can be greater customised towards participants based upon their individual strengths and weakness identified at the start of the study. This method of customisation would require the level of difficulty to change individually for each type of training.

Static difficulty

In this style of game the user has to complete as many iterations of a task as possible within a given period of time where the difficulty doesn't change. An example of this would be a user having to solve as many maths problems, or type as many words beginning with the last letter of the previous word as they can in one minute. Progress is measured by the number of iterations in each play through.

Increasing difficulty

In an increasing difficulty timed game, the longer player plays the tasks become more challenging. The player's progression is marked by the amount of time the player manages to successfully complete the task.

An example of this is pressing a button when an image appears at a certain point on the screen; the image reaches the given point quicker every iteration until the player fails.

6.3.2.1 Managing progression through levels of difficulty

Managing the difficulty of the game is important in order to enable feelings of flow, mastery and self-efficacy. There are many ways of modifying difficulty in a game, including fixed logarithmic curve, fixed increasing linear, fixed increasing wave, widening interval, widening logarithmic interval (Larsen 2010). Some of these are directly applicable to cognitive games in DOREMI. When graphing difficulty the attained proficiency level is usually displayed on the y axis, and amount of time playing the game along the x axis giving a representation of skill progression over time.

Fixed logarithmic

A fixed logarithmic curve allows for quick progression to the players level of skill for the given task and provides a consistent change in difficulty to keep players engaged. This curve addresses the fact that once a player has mastered the different aspects of the game the increase in skill needed to progress declines. The challenge then comes from complexity rather than from learning new methods of game play.

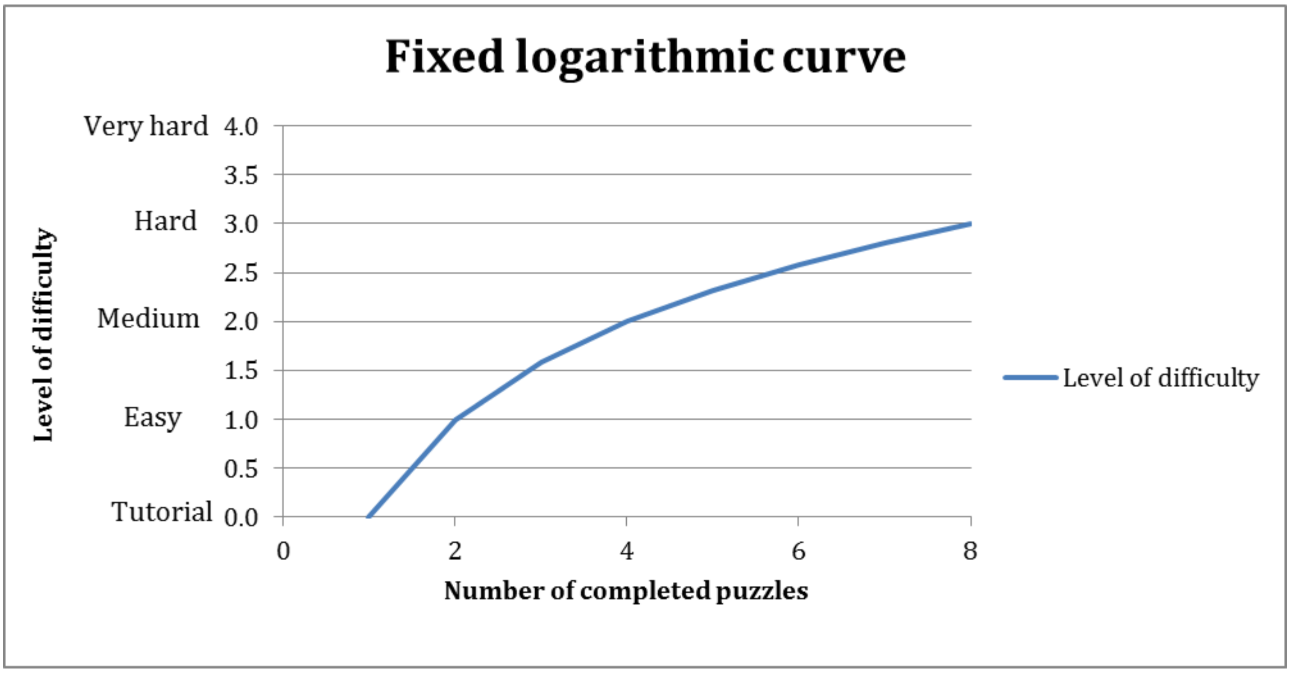

Figure 11. Fixed logarithmic curve

Fixed increasing linear

A fixed increasing linear difficulty progression provides a steady increase in difficulty. This type of difficulty progression doesn't accommodate for changes how an individual player’s skill progresses. Consequently, it can lead to less engagement from players who progress at different rates.

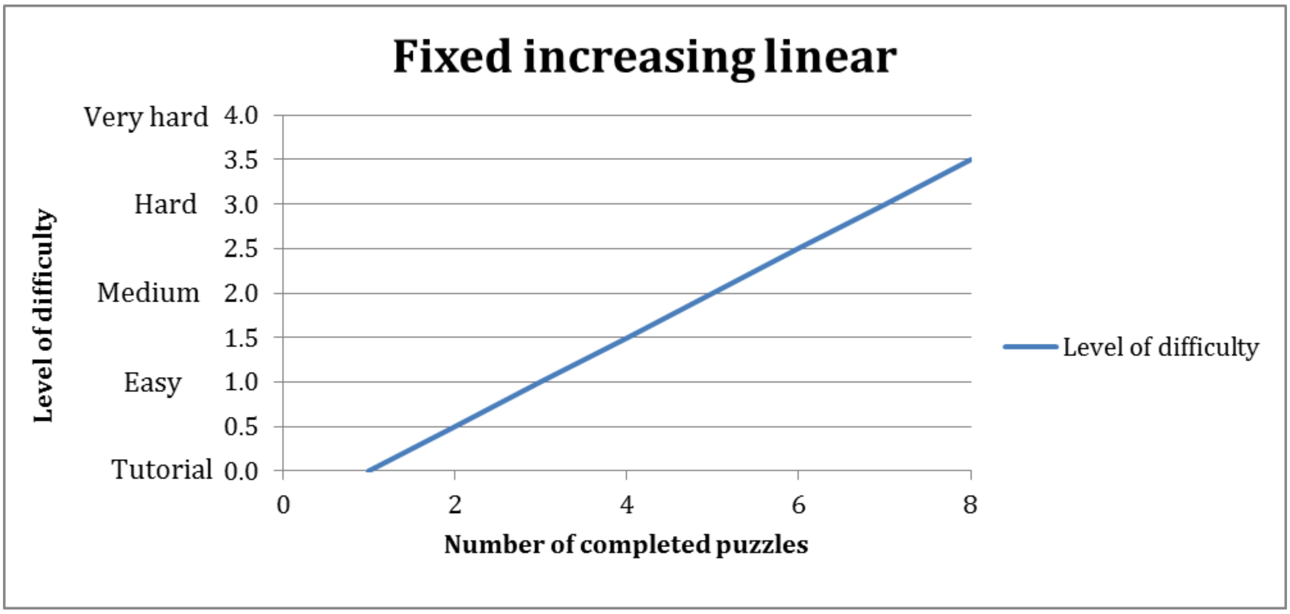

Figure 12. Fixed increasing linear

Fixed increasing wave

A fixed increasing wave creates plateaus at different levels of difficulties. This creates a more engaging level of play as players gain a sense of mastery on each plateau before difficulty increases. Care is needed to avoid too dramatic levels of difficulty increase between plateaus.

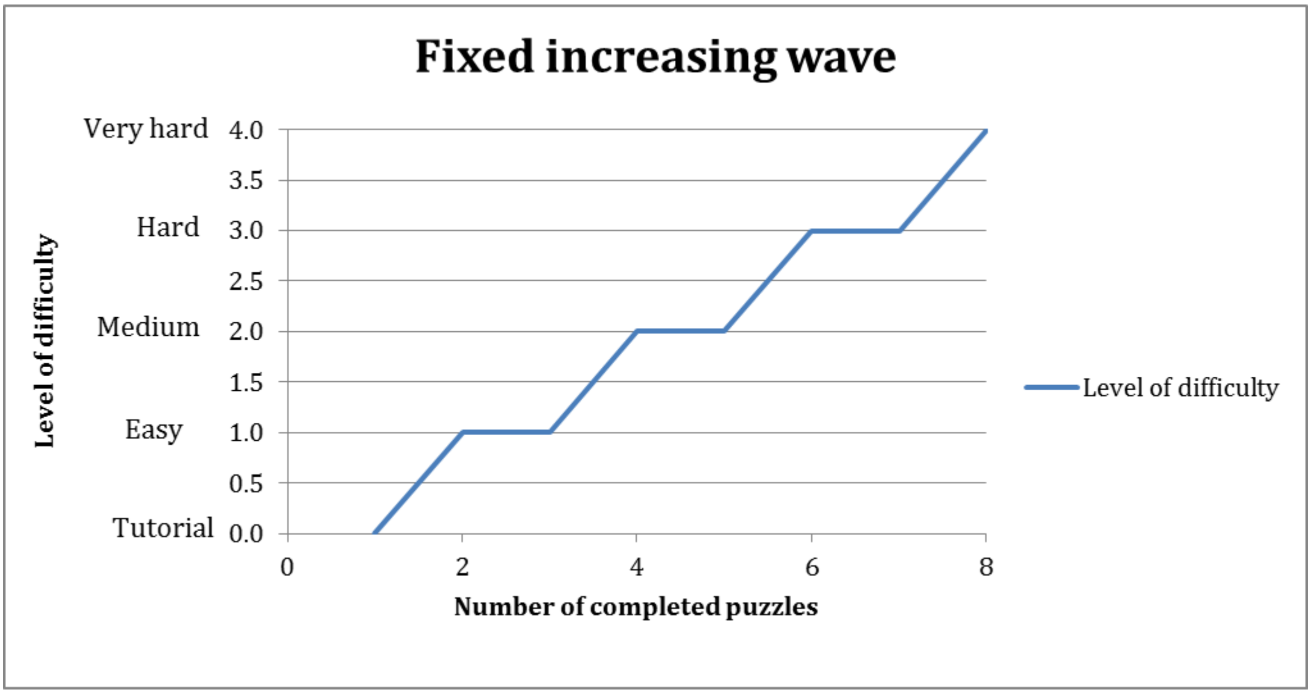

Figure 13. Fixed increasing wave

Widening interval

A difficulty interval is a range of levels of difficulties at a given point in the progression through the game where difficulty can be assigned randomly within the bounds of the interval. A widening interval allows for greater control over the initial level of difficulty. The use of a widening interval can lead to too much fluctuation in difficulty. This provides less control over the level of difficulty as the game progresses.

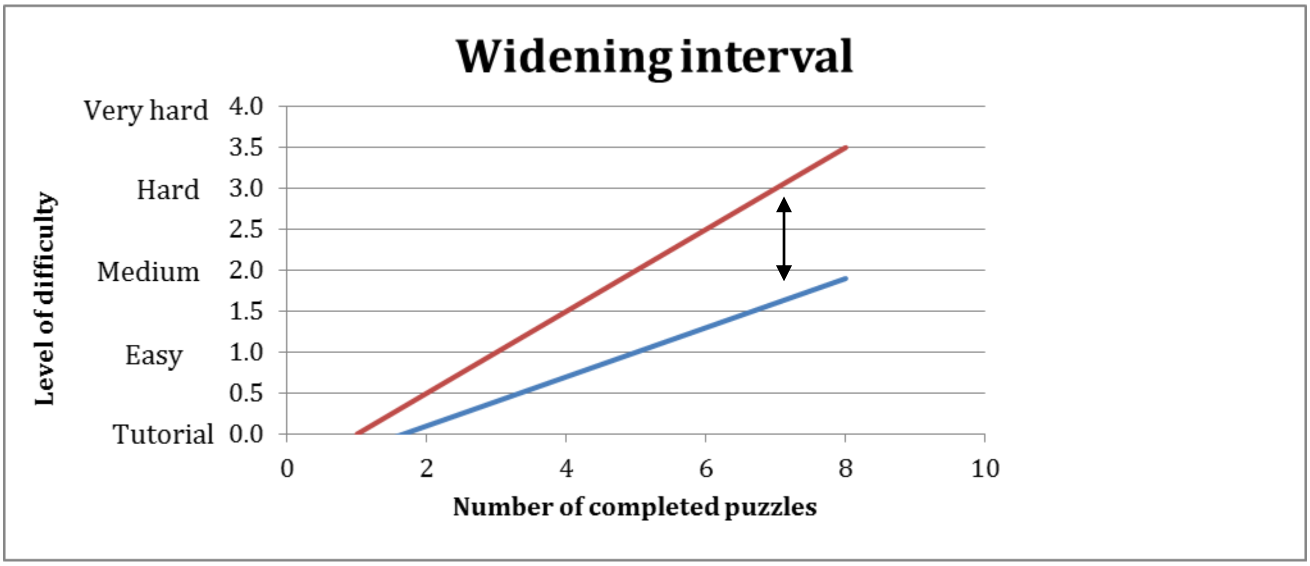

Figure 14. Widening interval

Widening logarithmic interval

Widening logarithmic intervals are the equivalent idea where the underlying difficulty progression is the logarithmic curve. This allows for a narrower interval and greater control as well as a guaranteed increase in difficulty over time. Due to the decrease in gradient of a logarithmic graph, a smaller interval is created in later progression than is created with the widening interval method.

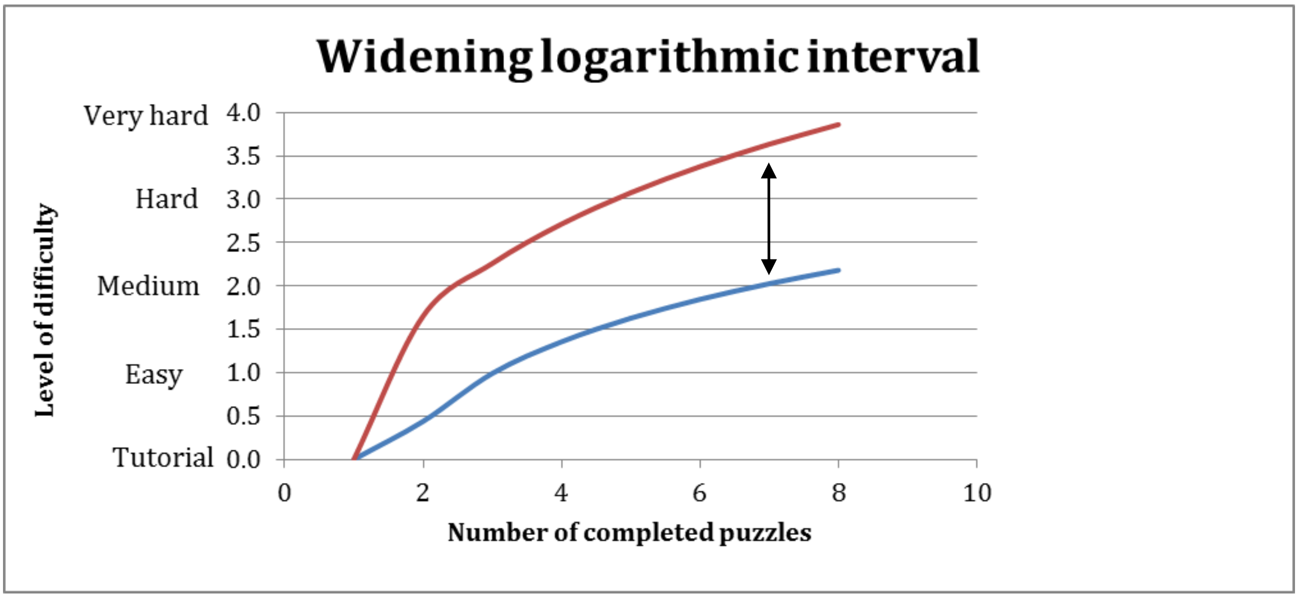

Figure 15. Widening logarithmic interval

6.3.3 Cognitive games levels

Managing the difficulty of the game is important in order to enable feelings of flow, mastery and self-efficacy. Typically, cognitive training systems start all participants at the lowest level of difficulty, moving participants up a level immediately if the first attempt at each level is correctly completed.

D2.2 suggested that participant start level would be decided upon depending on the baseline cognition characteristics of each participant identified by cognitive tests (MMSE, Phonemic fluency test, Semantic fluency test, Token Test, Digit Span test, Reaction time test and MoCA) for the DOREMI intervention in WP6. When DOREMI is commercialised, it may be difficult to categorise participants in this way as it will depend on the prescribing physician's access, license for, and willingness to complete these specific tests. Additionally, if completion of cognitive tasks is to be gamified, scores will need to be balanced so that somebody with better cognitive capacity does not have an instant head start on a leader board (instantly playing high scoring levels) over somebody with poor cognition (playing lower scoring levels).

An alternative solution is that all participants start at the lowest level of difficulty of cognitive game. It is not likely that the user will become demotivated by initial levels which meet their ability because the nature of cognitive training is such that progression through initial levels is quick, serving the purpose of teaching people to play the game and building player confidence. After the initial training levels, individuals can progress to a level of difficulty which challenges their ability.

6.3.4 Gamified exercise activities levels

Rather than playing a game, the exercise protocols will be met using gamified real-world exercise activities. DOREMI participants will progress through three levels of physical activity of increasing intensity. DOREMI participants will be assessed for physical abilities at baseline to assess their start level but it is likely that participants will start at Level 1. Later in Chapter 8, a more detailed proposal for a gamified exercise system using points, levels and achievements, is proposed.

Table 3. Exercise activity levels

Level	Activity required to achieve level increase
Level 1	3 outdoor sessions + 2 indoor each week sessions for a total of 195 minutes (WHO 2010 recommended guidelines.
Level 2	3 outdoor sessions + 2 indoor sessions each week for a total of 235 minutes (WHO 2010 recommended guidelines)
Level 3	3 outdoor sessions + 2 indoor sessions each week for a total of 260 minutes (WHO 2010 recommended guidelines)

6.3.5 Gamified nutrition activities levels

For nutrition activities to be gamified as part of DOREMI, it is proposed that all users begin in the same position. Users could monitor their food intake with an outsourced software which could feed data into the

DOREMI system. As this would not be a game as such, although there will be personal targets and milestones defined which will be gamified, no games levels will be defined.

6.3.6 Gamified social interaction activities

Gamification for social interaction is to some extent based on the common gamification mechanisms of points, badges and leaderboards principles that are used in gamified products. However, social interactions tool also considerer additional functionalities such as reputation and group identification that address the social component of the tool and would strength the engagement of the individuals to address the goals assigned in the gaming session.

To this end **Table 4** describe the key elements for the gamification of social interaction in DOREMI on the based of the measuring systems defined in the Deliverable D2.2 and the basic functions supporting social interaction activities that will be discussed in paragraph 7.4 of this report.

Table 4. Gamified social interaction in DOREMI

Basic functions of supporting the social interaction activities	Description	Variable to be considered
Goal setting	It aims at challenging users to meet the mark that is set for them. In the DOREMI case this would be implemented on the bases of the degree of adherence with the prescription of both the diet regime and the physical exercises assigned to the aging person.	Goal settings have to be considered for the following element of DOREMI gamified environment: • Exergames. • Dietary prescription. • Cognitive game.
Instructions	It aims at providing users with the engagement rules set up for using the system.	They would describe the following elements: • Rules for addressing the goal settings and defining the status/affiliation of user. • Rules for defining reputation level of a DOREMI user. • Rules for group identification.
Reputation	It provides information on the basis of which reputation assessment can be made. In the case of DOREMI reputational mechanisms can be based on the interest of the user in perceiving the goal setting and in the frequency of his/her interaction (virtual and physical) with the other community members as well as in the number of friendships and preferences that he/she got from the community members and from outside.	Elements to be considered in defining the algorithm assessing the reputation of a DOREMI participant would be: • Degree of (physical) social inclusion (see D2.2, §6). • Degree of (virtual) social inclusion (e.g. logs measurement; preferences gained from other community members; number of friendship; see D2.2; §6). • Capability to perceive the goal settings.

Status/Affirmation	It represents the achievements of the user of the system and communicates one's past accomplishment without explicit bragging. In the case of DOREMI this would be implemented on the bases of the degree of fulfilment of the goal settings (see the first bullet point above) with a scoring system that increase/decrease the status according to the degree of achievement of the defined goals.	Elements to be considered in defining the algorithm assessing the Status/Affirmation of a DOREMI participant would be: • Degree of achievement exergames goals (see also sub-paragraph 6.3.3) • Degree of achievement dietary goals (see also sub-paragraph 6.3.4) • Degree of achievement cognitive game goals (see also paragraph 6.3)
Group identification	**i**t aims at defining which are the shared activities that bind a group of users together around shared experiences. In case of DOREMI project this function is important to support the constituency of cluster of users (e.g. the ones only interested to the physical exercises and that could find in the social gamified environment the opportunity to share this common interest with persons with similar characteristics, ore ones, at the opposite, only interested in on-line games that what to stay in contact with persons with the same interest).	They would be based on the characteristics of the gamification environment of DOREMI and they would allow to define clusters on the bases of: • Single typology of tasks (exergame, dietary activity, cognitive). • A mix of the above typology of tasks.

6.4 User-centred design focus group activities

The user-centred design activities will be conducted with participants from Italy and the UK with similar characteristics to the DOREMI target users, and a reference group of older adults with normal cognitive function. There will be a group of around 8 people with MCI and normal cognition in both Italy and the UK (approximately 16 people in total). These users will form the DOREMI reference group and will be retained for all DOREMI user-centred design activities. The procedure for DOREMI user centred design activities is as below:

First focus group series

Aim: To establish the needs, motivations and limitations of DOREMI participants and to generate ideas for game concepts. The ideas generated in these focus groups will be analysed by the research teams at DMU, SI4LIFE and Imaginary and used to shortlist a series of existing games to present to the same users in a second round of focus groups.

Second focus group series

Aim: To present a selection of existing games (chosen with the ideas generated by focus groups series 1 in mind) and discuss design characteristics in focus groups.

Third focus group series

Aim: To present prototype DOREMI games and interface based on information from the Idea Generation and Design stage focus groups. Gather user-feedback from interaction with the game

Usability feedback from the focus groups will be analysed qualitatively. The cycle shown in Figure 10 will recommence. Usability problems will be addressed with further consideration of design issues, which will be incorporated into the prototype and user tested again with the same participants. Data will be analysed and the iterative process will continue until the users and the research team are satisfied with the quality, accessibility and functionality of the game.

6.4.1 First focus group series (Idea generation) methodology

This research involved discussion groups with older people recruited from retirement communities in the UK and in Italy to gain insight into the types of activities, hobbies and games that older users may enjoy in order to inform the design and development of appropriate prototype games. The preliminary results and methodology below relate to the UK arm of this study.

Research objectives

Main objective

To gather information from older people about participation in gaming activities in order to inform future development of a package of games and game-like activities related to DOREMI active ageing protocols.

Secondary objectives

To gather information on the opinions of older people on:

- Types of non-computer games and activities enjoyed
- Types of computer games and computer activities enjoyed
- Hobbies

To identify any national or cultural differences in games interests and motivations.

Research question

What is the ideal content of computer games and activities which are designed specifically for older users?

Study design

Residents of the retirement community Lark Hill Extra Care in Nottingham, UK were invited to take part in a discussion group. Discussions were led using a semi-structured question schedule which was designed to elicit information on activities and games enjoyed by participants. The transcription was consulted to draw inferences about the types of activities enjoyed by the target population and this information will be used to inform games design in later stages.

Inclusion criteria:

- 65-80 years of age
- Living alone within the retirement community (not sharing an accommodation with spouse, partner etc.)

- Able to give informed consent
- Half of the participants to have normal cognitive functioning (defined by a MMSE score between 25 and 30) and half having mild cognitive decline (defined by a MMSE score between 22 and 24). The MMSE is a brief screening tool to provide a quantitative assessment of cognitive impairment and to record cognitive changes over time. Scores between 22 and 30 suggest normal cognitive functioning or mild cognitive decline. People with scores between 0 and 21 will be excluded as this indicates more severe cognitive impairments.
- As the main DOREMI project involves a 50/50 gender split, half of the participants to be male and half female.

Exclusion criteria:
- Non-English speakers (UK study)
- Any speech, vision or hearing problems which may interfere with taking part in the discussion group.

Recruitment

Recruitment for the focus groups relied on residents responding independently to a leaflet posted at their residence. In total, 426 residents received the study information but none of the potential participants who responded and agreed to be screened with the MMSE could be categorised as having mild cognitive impairment. A decision was made to continue with this first focus group, despite all participants having normal cognitive functioning. For this reason, results presented here should be treated cautiously. Whilst definitely offering some indication of the types of activities enjoyed by older people, these findings may not necessarily reflect the same interests, motivations and barriers faced by persons with mild cognitive impairment. Interested participants had the opportunity to ask questions about the research. One week after receiving the information sheet, participants were contacted by the Extra Care project representative asking if they were still interested and would like to consent to take part. Participants were assured that they were not obliged to take part and informed again about their right to withdraw after consenting. Participants could choose to have a friend, relative or care worker with them at this consent meeting.

The difficulty recruiting suitable participants for focus groups may suggest that recruiting similar people for the DOREMI pilot intervention could be more difficult than previously anticipated. Extra Care staff are now investigating alternative strategies for recruiting people with MCI for further user-centred design activities in WP5, such as approaching people with cognitive impairment on a one-to-one basis to explain the study in more detail.

Participants

Nine residents (5 male) of the Lark Hill Extra Care facility took part in the first UK focus group in September 2014. The average age of participants was 77 (range 67-89). Participants all had normal cognitive functioning as defined by MMSE scores between 28 and 30. One participant, (Male, aged 71, MMSE=30) left the focus group halfway through, stating that the topic was not something he was interested in. He had not spoken during the focus group so was excluded from the analysis below.

Table 5. Participant characteristics

Participant number	Gender	Age (years)	MMSE score (out of 30)

P1	Male	79	28
P2	Male	87	28
P3	Female	67	30
P4	Male	71	30
P5	Male	71	30
P6	Female	89	30
P7	Male	80	30
P8	Female	73	30
P9	Female	76	28

Method

The focus group lasted 68 minutes and took place in a meeting room at the Extra Care facility. Residents were asked to sit around a table along with three members of the De Montfort University team and an Extra Care staff member who was already known to the participants. The dictaphone was placed in the middle of the table, participants were reminded that they were being recorded and the aim of the focus group was briefly explained again. Participants were asked to complete an icebreaker exercise, "Tell us your name, and something interesting about yourself", before the first question from the focus group schedule was asked. The discussion schedule was loosely followed and natural discussion between participants (on topic) was encouraged. Following the discussion group, the recording was transcribed, removing participant names and any identifying information. Prior to the discussion groups, a series of topics of interest were defined by the research team (see below). The transcription was consulted by DMU and IMA to identify information relevant to the defined topics of interest.

Ethical issues

Safeguards for working with vulnerable population

The target population for this study could be seen as vulnerable in that they some of them have age-related deficits in cognition. Additionally, as Extra Care staff was involved in the recruitment process, there was potential for the target participants to feel that they had less autonomy in choosing to participate. Following the British Psychological Society (British Psychological Society, 2010) recommendations for working with vulnerable populations, the researchers ensured that participants were "given ample opportunity to understand the nature, purpose and anticipated outcomes of any research participation, so that they may give consent to the extent that their capabilities allow". Consent forms and information sheets were written in lay terms in a large font to maximise the participants' understanding of the study. Participants were given ample time (1 week) between being given the information sheet and being asked to give consent so that they had time to process the information and contact the researcher if they have any questions. When taking consent from the participants, the study was explained again and the participant had chance to ask any further questions. Following the study, participants were given a debrief sheet written in lay terms which included the researchers contact details (post, telephone and email) in case of any further questions.

Informed consent

Prior to participation, participants were fully informed about the purpose of the research and their involvement in the study via the Participant Information Sheet. Participants were also asked to complete a Consent Form. The Consent Form comprised of a series of statements relating to the study requirements. Participants were asked to read, check and initial these statements in order to indicate understanding of their involvement and confirm their given consent to take part. Participants were told that they could choose to have a friend, relative or care worker present during the consent procedure and that they were not obliged to take part.

Rights to Withdraw

The Participant Information Sheet, Consent Form and Debriefing Sheet all explained participants' rights to withdraw from the study. Participants had the right to withdraw at any stage during the focus group although due to the inter-dependent nature of group discussions, participants were not able to withdraw their data after the discussion had commenced.

Debriefing

Following the discussion group, participants were verbally debriefed and provided with a full written debrief which they were asked to read and retain for future reference. The debrief sheet recapped on some of the information initially outlined in the Participant Information Sheet and Consent Form, including the purpose of the research and participant involvement, plus provided further information concerning participation rights and details pertaining to post-study support, i.e. contact details for the researcher, how to complain if there was a problem etc.

Confidentiality and Anonymity

Although it was not anticipated that any sensitive information would be divulged in the discussion groups, names of participants were replaced with pseudonyms in order to protect the anonymity of participants. Personal information was stored and processed in accordance with data protection legislation. Data was stored on a password protected computer in a locked office and only accessed by the researchers on the project.

Security of data: Protection and storage

Discussion group data was recorded and stored onto a digital dictaphone maintained by the researcher. After the discussion group, the researcher transferred the recorded sound files from the dictaphone to a password-protected computer and encrypted USB drive (for back-up purposes) that are accessible only by the named researchers. The recorded sound files were then deleted from the dictaphone. Written transcripts produced from the recorded sound files were stored on the same protected devices. Hard copy records are kept in a locked filing cabinet in a locked office. Any data that is written up into a report will not be traceable to any individual participant. Any data generated by the project will be kept for 5 years in line with the DMU data storage policy and then destroyed.

Discussion schedule

Introduction

>Researchers introduce themselves, who they are, which institution they are from>

"We are working on a project to develop games for people ages 65-80 which are designed to improve health and wellbeing. We would like your input on the types of activities and hobbies that you enjoy so that we can design games that are suitable for people like you.

To start with it would be good if we could go around the table so that you can introduce yourselves. Tell everybody your name and a little bit about yourself.

We are interested in developing new computer games specifically designed for an older target market. We would like your opinions on other types of games and hobbies that you participate in so that we can use this to inform the design".

Part 1- Activities

What kind of recreational activities do you like?

Prompts-sports, socialisizing, reading?

What are your interests?

Prompts- Animals , history, crafts?

Do you take part in any activities to maintain or improve your health?

Prompts- Exercise, dieting group?

Is there anything else you do to maintain or improve your health?

Prompts –Government health initiatives (like Eat '5 fruit or vegetables a day, drink 2 litres water a day), or Sudoku etc.

Part 2: Games in general

Do you play games?

Prompts- board games, puzzle books, sports

If **No**- Why don't you play games?

Prompts- barriers to playing, lack of opportunity, bad prior experience, don't like games

If **No**- What would make games more appealing to you?

What do you like about playing games?

What is the main benefit for you when playing computer games?

What motivates you to play games?

What is the least enjoyable part about playing computer games?

Do you play games alone or with other people?

Prompts- with family, with other residents, alone

Would you like to play games against other people?

Prompts- Competition, leader board, rewards

Do you play any games specifically to improve your health and wellbeing? What do you like about them?

Prompts- Sudoku, chess, table tennis

What other hobbies do you enjoy? What do you like about them?

Prompts- crafts, sports, socialising

Do you participate in any other activities to improve your health and wellbeing?

Prompts- sports, Weightwatchers, meditation

Part 3: general questions about computer games

Do you use a computer? What kind of device

Prompts- desktop, laptop, tablet, Wii etc.

If **No**- Why don't you use computing technology?

Prompts- barriers to technology, lack of opportunity, bad prior experience, don't like technology

If **No**- What would make computing technology more appealing to you?

What do you like about using this technology?

What don't you like about using this technology?

What motivates you to use technology?

Prompts- email family, use internet to keep up with interests etc.

Do you play computer games? What kind of games do you play?

Prompts – solitaire, Wii fit etc.

If **No**- Why don't you play computer games?

Prompts- barriers to technology, lack of opportunity, bad prior experience, don't like computer games

If **No**- What would make computer games more appealing to you?

What do you normally play computer games on?

Prompts- PC, Xbox, iPad etc.

Do you enjoy playing computer games?

Prompts- if so, why? If not, why not?

What kinds of computer games do you prefer?

Prompts- puzzle games, exercise games, role play games

Do you play computer games alone or with other people?

Prompts- with family, with other residents, alone

Would you like to play games against other people?

Prompts- Competition, leader board, rewards

Would you like to play computer games more often?

Are there any barriers or challenges that may stop you from playing computer games?

What is the main benefit for you when playing computer games?

What is the least enjoyable part about playing computer games?

Do you play any computer games for health and wellbeing?

Prompts-brain training, Wii fit

"Do you have any questions for us or anything else you would like to say about the topics we have discussed?

Thank you for participating today. Your advice is really valuable to us in the development of games to promote health and wellbeing".

6.4.2 Focus group results

Information from the focus groups are presented below under a series of headings based upon predefined topics of interest.

Activities enjoyed

All participants reported living active lives, enjoying a wide array of activities including literature, travel, sports, music and computing. The wide range of activities described by these participants may be due to their residential status. The Extra Care facility offers a vast array of classes and has many facilities for indoor and outdoor activities such as gardening, gym etc. (A full list of all activities enjoyed by participants and mentioned during the focus groups is reported in the appendix). Having a full active life was viewed by one participant as a way of passing the time and by another as a way of maintaining psychophysiological health.

"And all these activities, they keep you going. You're not just sitting there".

Participant 9, Female, 76y, MMSE 28

"Keep your mind active, keep your body active. It keeps you younger".

Participant 7, Male, 80y, MMSE 30

Activities were not limited to those available in the residential village. Travel, seeing new places and learning about different cultures was mentioned multiple times by the participants. The social element of being involved in activities was the main motivation for participants. Loneliness and social isolation was discussed as being detrimental to health. Some of the participants were involved in encouraging other residents in the care home to be involved in social activities.

"Loneliness is the worst illness of the lot".

Participant 6, Female, 89y, MMSE 30

"You get some older people who are stuck in their rooms and they don't get involved you know… we've got this one lady who didn't come out for years, now are getting her out and involved in more activities".

Participant 7, Male, 80y, MMSE 30

Games enjoyed

Seven of the participants reported playing games. Trivia and puzzle type games were popular, as were traditional card games, such as solitaire and poker. The one participant who reported not playing games at all suggested that they were something she didn't have time for as she was very active outdoors. That said, she suggested that game playing may be something she would consider if she became less able to complete her outdoor activities.

"I don't play games at all… I'd just rather be out doing things. If I get to the stage when I can't go out then maybe I will turn to that"

Participants 8, Female, 73y, MMSE 30

Participant game playing was not limited to traditional games. Some of the participants were active in searching for online games that interested them online.

"I found a game on Facebook called Triviador… it's not general knowledge aimed at the UK but global general knowledge… it's quite good actually because you play against people, live".

Participant 5, Male, 71y, MMSE 30

When asked about whether they would be interested in trying out new games as well as traditional games, the two participants below discussed being open to trying new games, especially as trying a new game could mean interacting with other people.

"You've got to be open to all things really, you might not like them and think "that's not for me", but if you won't try them you won't know".

Participant 9, Female, 76y, MMSE 28

"I think it's participation with other people that's the key. It doesn't matter what it is. You can play with other people."

Participant 3, Female, 67y, MMSE 30

As previously discussed, participants enjoyed the social element of an active life and this extended to game playing. Those who played games enjoyed to play with or against other people, whether face to face when playing a game such as golf or playing games with others online.

"Golf provides companionship, friendship, competition, exercise".

Participant 1, Male. 79y, MMSE 28

"[playing games online] helps keep your mind active, and you're in touch with other people".

Participant 7, Male, 80y, MMSE 30

Five of the participants reported playing games online, competing against siblings, grandchildren, Facebook friends or other anonymous online players, although it was important for participants that they were fairly matched with their online opponents. Some of the participants had experience using chat windows when playing games and had enjoyed exchanges with other people playing internationally.

"I play a lot [of Bridge] on the internet, with people from all the countries of the world. You just click on and play. It's terrific".

Participant 1, Male. 79y, MMSE 28

"I don't like playing games on the computers against young ones. My Great-Grandson is 10 and he wipes the floor with the lot of us, every game, every time"

Participant 7, Male, 80y, MMSE 30

Although game playing online appealed to participants, one reported preferring to play against other real people, rather than playing against the computer because computers have an unfair advantage, as reported below.

"[I don't like playing against the computer] because it's not human. Computers in chess for example cheat. If you sit down and play against Fred for example, you sit down and you remember a few moves etcetera, but the computer remembers all of the games that have been played…and it consults them when you make a move and it just finds the right one".

Participant 1, Male. 79y, MMSE 28

Experience with computers and computer games

Six of the participants reported using computers for online banking, shopping, social networking and Skype. Many of the participants had both a PC and a touchscreen device. The majority of the participants had smartphones. Of the two remaining participants, 1 used a computer for non-game activities only (e.g. Skype) and another never used computers, although she had some experience with them previously.

"I've got a laptop but I don't use it, I'm not keen on computers… because I don't know enough about it… I wrote one email and that was the end of it, I'd rather just sit and write a letter".

Participant 6, Female, 89y, MMSE 30

Although the participants were fairly computer literate, some of them reported age and health related problems with technology. This was largely related to age related deteriorations in vision and dexterity.

> *"I had an older computer for about 15 years which I could do quite well but then it's packed up altogether so I've got this new thing…and I find it very difficult to manipulate because of dexterity. It shoots off all over the place and I find this touch screen business quiet confusing, because my fingers are not sensitive like they used to be and I tend to press the wrong thing and it shoots off somewhere else."*
>
> ***Participant 2, Male, 87y, MMSE 28.***
>
> *"I really need [a computer] with bigger keys and more simple actually, that's the problem."*
>
> ***Participant 3, Female, 67y, MMSE 30.***
>
> *"I quite enjoy doing pen and paper crosswords but I find it irritating doing them on line because you've got to do this (demonstrates repeated clicking on screen). "*
>
> ***Participant 5, Male, 71y, MMSE 30.***

For another participant, computer technology had actually helped to modify an activity which she found more difficult with age: using a tablet to read books offered the opportunity to modify lighting and font size, something which would be impossible when reading a book in the traditional way.

> *"I've got books that I have picked up and I find very difficult to read now, whereas my Kindle I can read it perfect and I can hold it. You can make the type bigger and it's got the light behind it so you can see it".*
>
> ***Participant 3, Female, 67y, MMSE 30.***

Participants had some very specific suggestions about the way technology could be modified to make it more user-friendly for older people. In particular, making interfaces bigger, such as using a smart TV for the internet and minimising the use of hand held game controllers. One participant suggested that voice technology could be useful replacement for hand held controllers while another suggested creating an exercise game that involved enabling older people to take part in activities that they could no longer complete in reality.

> *"I'd say that games which are designed for elderly people which involve manual dexterity are probably a mistake because they're probably going to get worse".*
>
> ***Participant 1, Male. 79y, MMSE 28***
>
> *"You've got voice technology now so you could perhaps incorporate voice technology into games. I'm presuming it exists already".*
>
> ***Participant 5, Male, 71y, MMSE 30***
>
> *"I like sport.. football or athletics. I don't know if you could do one [a game] for athletics, football or stuff like that. Something that you might be able to participate in, although you're not. Do you know what I mean?"*

Participant 3, Female, 67y, MMSE 30.

Computer technology was viewed by the group as a useful way of providing passing the time when unable to complete normal activities due to bad health. Additionally, participants felt that games could offer some social interaction for older people who did not often leave the house.

"Around 12 years ago, I had a very painful knee for a long time and I played a lot of Bridge [online] at 4 o'clock in the morning and it's almost limitless, I could play all day".

Participant 1, Male. 79y, MMSE 28

"Even if it's on the computer and you're in your house and they're in theirs, to sort of get them out."

Participant 3, Female, 67y, MMSE 30.

Health and wellbeing

Although the participants felt that taking part in activities in general was good for cognitive health, they did not use any games or apps specifically for health and wellbeing, preferring to play for enjoyment and social connectedness. The participants did engage in a number of positive health behaviours which were non-game or technology based. Many of these were focused on physical activity.

"I think exercise is the main thing when you get to our age so I walk, I dance, I do tai-chi, I do yoga… the first thing I do in the morning when I get up is that I stretch up and then I stretch down because I think stretching is good for you, it keeps you agile".

Participant 9, Female, 76y, MMSE 28

"I do [my exercises] every morning.. and walking."

Participant 6, Female, 89y, MMSE 30

When presented with some suggestions of the types of health protocols which will be gamified in DOREMI, participants showed interest in exercise and cognitive activities but had strong opinions about being told what to do, particularly in terms of diet and nutrition decisions.

"We do resist being told what to eat and what to do".

Participants 8, Female, 73y, MMSE 30

"I know what good food is and what's good for me and what's bad for me, because it's quite bloody simple really."

Participant 5, Male, 71y, MMSE 30

6.4.2.1 Summary

On the whole, participants were more computer literate than expected, and it is likely that this group who self-selected to take part in a focus group about computer activities are not entirely representative of all older people. Participants were familiar with PC, laptop, tablet and smartphone technology and the majority enjoyed playing games either against other people or alone. Primarily, participants reported playing puzzle games or traditional card games on tablet computers. One of the key motivators for engaging in computer and non-computer gaming was social interaction. Participants were happy to try out new games if it meant there was an opportunity to engage with other people, be it family living outside of the residential home, friends on Facebook, international online players or other residents in the residential village. However, when playing games against other people on line, it was important to participants that their abilities were equally matched with those of their opponents. Participants reported playing puzzle and trivia games because they felt it improved or maintained their cognitive health but none of the participants used games or apps for any other health purpose. Participants were interested in the idea of playing games for exercise and physical health but showed resistance to using a game or app designed to improve nutritional health. Furthermore, participants felt that with age, physically interacting with computing technology had become more difficult due to age related decrements in vision and dexterity. On the whole, participants were positive about the use of technology, with many finding that computing devices could be used to support them in their daily activities. For example, the brightness and text adjustor on a Kindle made it easier for one participant to read a book now since her vision had deteriorated, and another participant found that online gaming was able to keep him entertained at home after suffering some acute mobility problems. Of the two participants who did not enjoying computers, one said that it was because she did not understand them and had received inadequate training and the other reported not having time to play games because she was very busy with other activities. In conclusion, although these participants may not fully meet the DOREMI target market characteristics, it is clear to see huge potential for the use of games and gamification with older people. The participants had a broad range of interests which offer a basis for development of age-appropriate prototype games for DOREMI. Furthermore, the finding that these older people do not use technology for health reasons suggests that participants could be resistant to some of the DOREMI gamified activities. This point will be further explored in the next focus group series when gamified health applications are presented to participants for review.

6.4 3 Intentions for further focus group rounds

Data from Italian focus groups following the same methodology will be compared with UK data to establish any cultural differences in game and activity preferences. The data gathered during the first round of focus groups will then be used to inform the structure and content of further rounds of focus groups. This will be reported later in WP5.

7. MARKET RESEARCH

7.1 Analysis of technologies and methods used to prevent cognitive decline

To maximise the potential efficacy of the DOREMI cognitive intervention, the design of the DOREMI cognitive games and gamified activities should be influenced by existing reviews of published studies in this area to establish the most appropriate areas of cognitive function to be targeted in a training game. The paucity of interventions targeting people with MCI and the heterogeneity of existing study methodology makes it difficult to establish the 'ideal' content of a cognitive training intervention to meet these desired outcomes. Nevertheless, we can draw on the broader evidence from successful cognitive interventions using healthy older adults and the fewer, but no less promising studies on training effectiveness in people with MCI, to inform the development of DOREMI cognitive games.

Methods typically used in research and clinical practice to improve or maintain cognitive functioning can be categorised into cognitive stimulation, cognitive training and cognitive rehabilitation (Clare & Woods, 2004). These terms are not interchangeable; cognitive stimulation usually involves group activity aimed at stimulating cognitive and social functioning; cognitive rehabilitation is an individualised approach which may involve training with a therapist using mnemonic strategies and finally; cognitive training, the strategy utilised in DOREMI, which involves guided repetitive practice on a set of tasks which have been designed to reflect particular cognitive functions such as memory, attention, language and executive functioning. It is argued by Gates, Sachdev, Singh, & Valenzuela, (2011) that this lack of a formal distinction between types of cognitive intervention can explain the inconsistent effectiveness of interventions using cognitive training reported in the scientific literature. In a true cognitive training intervention, participants are typically assessed using neuropsychological tests at baseline before completing a fixed number of cognitive training sessions (targeting one specific area of cognition or multiple areas). Following the training period, the same neuropsychological tests are administered in order to establish the effectiveness of the intervention in improving overall cognitive functioning and domain-specific functioning, e.g. Ball et al., (2002); Smith et al., (2009).

The desired outcomes of cognitive interventions for people with MCI are two-fold. First, the immediate effects of improved cognition could positively impact functional abilities, psychological wellbeing and quality of life. Second, cognitive interventions could delay the progression of MCI to dementia, which in turn has benefits for the individual, their family and public health systems (Woods & Clare, 2013). The IMPACT study trained 487 adults without cognitive impairment and aged >65 using Brain Fitness Program (Posit Science., 2009). The intervention comprised a series of 6 computerised exercises designed to improve speed and accuracy of auditory information processing. Following 40 hours of training (1 hr per day, 5 days a week for 8 weeks), participants showed significant improvements in the trained area of auditory memory and attention, in addition to improvements in untrained areas, including working memory, delayed recall and processing speed (Smith et al., 2009).

The ACTIVE trial (Ball et al., 2002) is a further example of successful cognitive training for cognitively normal older people using both computerised and non-computerised activities. Significant improvements were found for group training for; verbal episodic memory, reasoning exercises (ability to solve problems following a serial pattern) and computerised speed of processing training (visual search and identification of a stimuli), compared to a no-contact control group. There is less published research on cognitive training for people with MCI. A meta-analytic review of 15 published cognitive interventions for people with MCI found that people undertaking a cognitive intervention significantly improved in global cognition, episodic memory and executive functioning compared to control groups (Li et al., 2011). Although not reaching statistical significance, the following areas of interest all showed increases greater than that of the control group following cognitive training: MMSE score (Folstein, Folstein & McHugh, 1975), semantic memory, attention/processing speed, visuo-spatial ability, language; activities of daily living, depression and anxiety. A criticism of this review is that it included studies which used cognitive stimulation and rehabilitation techniques, in addition to those using cognitive training (making it difficult to partial out the benefits of cognitive training). In a more strictly defined review of cognitive training for people with MCI, (Gates, Sachdev, Singh, & Valenzuela, 2011) cognitive training interventions were shown to have moderate-large beneficial effects on memory outcomes.

The majority of studies used purpose built cognitive training packages to train participants which were not available for review, although there are many commercially available games and applications which claim to improve cognitive functioning, some of which are reviewed below.

7.2 Market research on cognitive training games

Cognitive training games are typically puzzle-type games with simple graphics and clear objectives, designed to be played for a few minutes at a time. To establish the current market status of cognitive training games and applications, the following databases were systematically searched during May and June 2014: Apple store, Xbox live marketplace, Play store; Steam; Origin; Big fish; Facebook Games, Nintendo store; Ratuken's Play; GoG. Each database was searched with the following search terms to identify suitable games for review: Cognitive; Brain; Cognition; Memory; Puzzle; Attention; Focus; Mind; Perception; Language; Problem solving; Reasoning; Executive control. Games were considered suitable for review if they met the following criteria: aimed at adults and claiming to train, improve or maintain any area of cognitive functioning. Of particular interest were games which claimed some scientific evidence.

The search identified 364 games or apps which fit the criteria. This comprised of 118 packages of cognitive training, which typically included a series of mini games targeting areas of memory and attention, and 246 standalone games claiming to target different areas of cognition. The majority of these were located on the Apple store and Google Play store, designed to be played on a tablet or touchscreen smartphone. A database of located cognitive training games is available for reference during the development of the DOREMI gamified environment.

The search identified that memory and attention were the most frequently targeted areas of cognition (perhaps because these areas are easy to capture in game form), with other games covering language and numeracy skills. Many games were based on existing neuropsychological tests known to capture specific areas of cognitive functioning. The best examples of games which claim to train domains of cognition are outlined below:

7.2.1 Memory

7.2.1.1 Short term memory

Short term memory refers to our ability to hold a limited amount of information in a very accessible state temporarily (Cowan, 2008). The majority of short term memory games also combined some element of attentional focus. A popular game involves remembering sequence of stimuli presented on screen. This could take the form of recalling the sequence in which a coloured shape flashed on the screen (e.g. Repeated; Pineapple Media, 2013) or to recall a change in two sets of stimuli. In the example from the Rosetta Stone Fit Brains app (Rosetta Stone Canada Inc., 2014), a series of numbers and letters are presented on the screen before being removed, then returned with one digit missing (see Figure 16). The user must identify which digit is now missing. The number of digits increases in intensity to increase the level of challenge. If failing a series of 4 digits, the level does not increase to 5 digits until the series of 4 digits is completed successfully (in a similar way to the Digit Span test used as an outcome measure in DOREMI (see D2.2). An alternative is to present a photograph or drawing on the screen and then take it away before presenting the same image with a key detail missing and asking the user to 'spot the difference' e.g. MemMagic (Anusen, 2012).

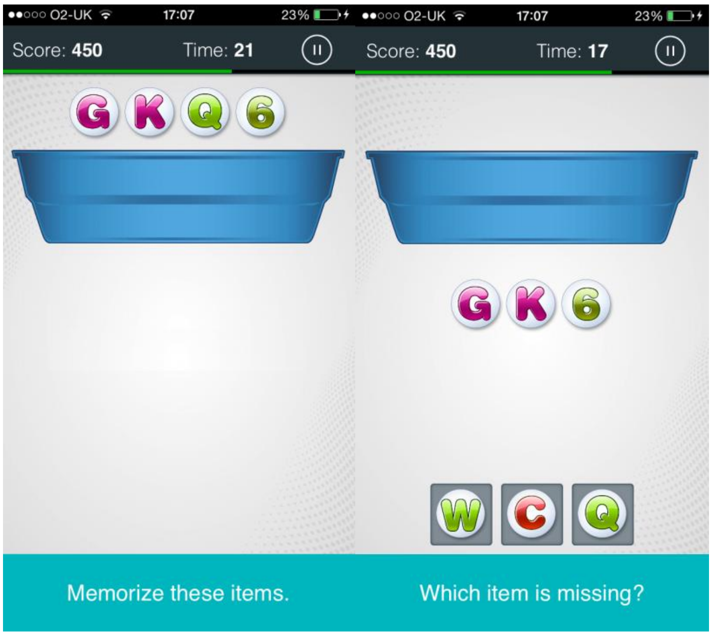

Figure 16. Short term memory game for digits and symbols in Fit Brains app

7.2.1.2 Working memory

Working memory utilises short term memory but refers to our ability to process and maintain one set of information whilst completing a task (Baddeley, 1992). For example, remembering the order of number to dial when a phone number is read out to us. One of the most frequently published games designed to train working memory is a variation on a pair matching task, where players are required to remember the location of an increasing number of paired items on a grid (see Figure 17 for an example from the game Fruit Smiley Brain Games (Hatch Media LLC., 2013). This game is based on the Paired Associates Learning task which is often used in neuropsychological assessments (Wechsler, 2008). The user is required to hold the position of multiple cards in their memory whilst continuing to uncover new cards. The pair matching task is increased in difficulty by increasing the number of images to match or including a timer. Pair matching games can be played single player or competitively (e.g. Best Memory Matching Game; Dainty Game., 2014).

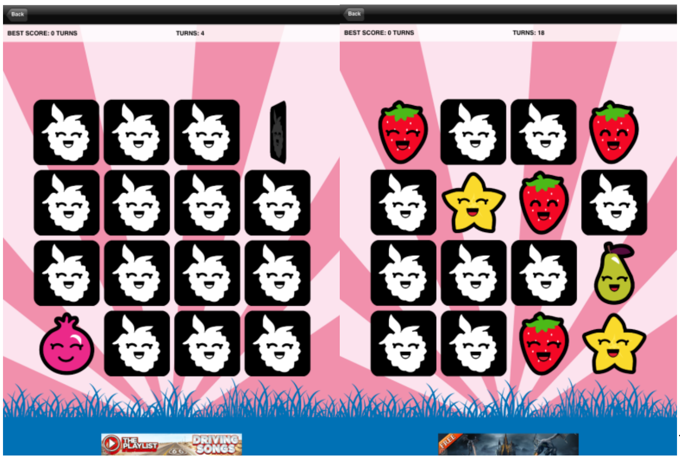

Figure 17. Images from 'Fruit Smiley Brain Games'; a pair matching game designed to train memory.

An alternative working memory task is a computerised version of the 'N-back' test. In the classic N-back test, a sequence of stimuli is presented and user is asked to identify when the current stimulus matches the one from *n* steps earlier in the sequence. In the N-back test from the Lumosity training series (Lumos Labs Inc., 2014), a series of symbols are presented and the user needs to press 'Yes' or 'No' to identify if the symbol matches the previously presented symbol (see Figure 18). In the Lumosity example, the task is timed and requires the user to remember 1 symbol previously (1 N-back) but the intensity of the task can be raised by increasing the number of numbers back the user needs to remember (2 or 3 N-back).

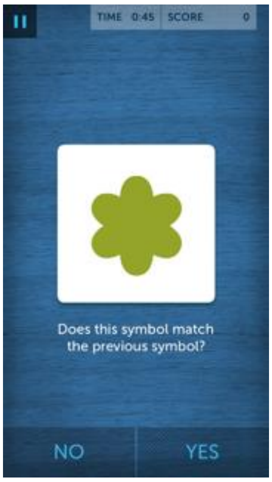

Figure 18. N-back working memory task from Lumosity brain training

7.2.2 Visuo-spatial skills

There were fewer games targeted at training visuo-spatial functioning. Visuo-spatial skills relate to our ability to mentally process and interpret visual information about where objects are in space. Visuo-spatial skills are necessary for solving puzzles, and for navigating ourselves from one place to the next whilst avoiding obstacles. One game which trained spatial memory involved memorising the location and pattern of tiles that flip over on a grid (see Figure 19). Difficulty was increased with increasing numbers of tiles. Versions of this game featured as mini games in Mind Games- Brain Training (Mind Games Consulting Inc., 2014)and Lumosity (Lumos Labs Inc., 2014) cognitive training packages.

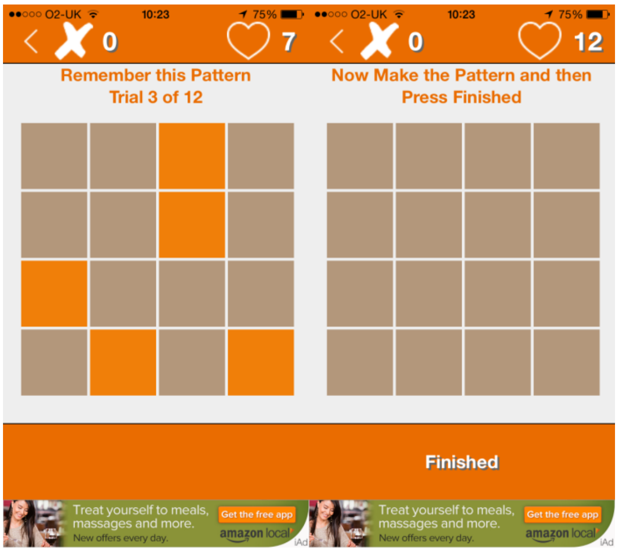

Figure 19. Visuospatial memory task from Mind Games-Brain Training

Lumosity is one of the few training packages to offer games which claim to train visuo-spatial skills (Lumos Labs Inc., 2014). One example requires the user to add an item to a suitcase, so that the case will be able to close. This requires the player to mentally visualise the suitcase in 3D space.

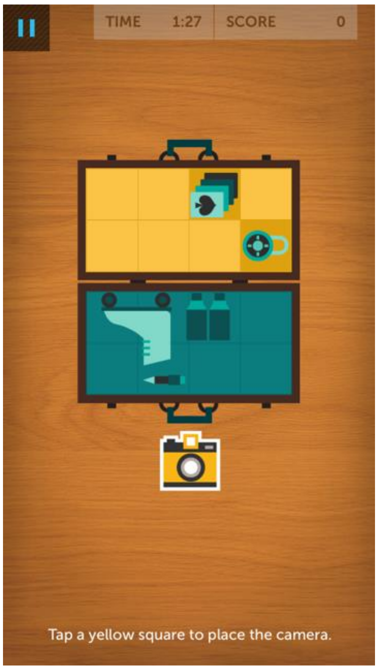

Figure 20. Visuo-spatial functioning game in Lumosity

7.2.3 Attention

Attention refers to the ability to filter out multiple stimuli in order to focus on one particular task or stimulus. Many of the games located which aimed to train short term memory also require attentional focus (see above). Multiple versions of attention games based on the Trail Making Test (Reitan, 1958) were located. Trail making is a neuropsychological assessment which requires the user to visually scan a series of numbers or letters and quickly tap them in ascending order. In Quick Thinker (Maverick R & D, 2013) numbers are presented in a grid form. Users are initially presents the player with a matrix from 1-50 in a random order (see Figure 21). The difficulty level can be increased to up to 1000 digits. The user is required to tap each of the digits in ascending order as fast as they can.

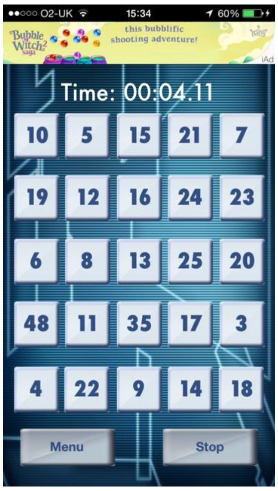

Figure 21. Attentional matrix task in the Quick Thinker App

An alternative method of training attention is a ‘spot the difference’ type game. Joggle brain training (Joggle Research, 2014) presents simple drawings and asks the user to click a paperclip if the items match and a dustbin if they do not match (see Figure 22).

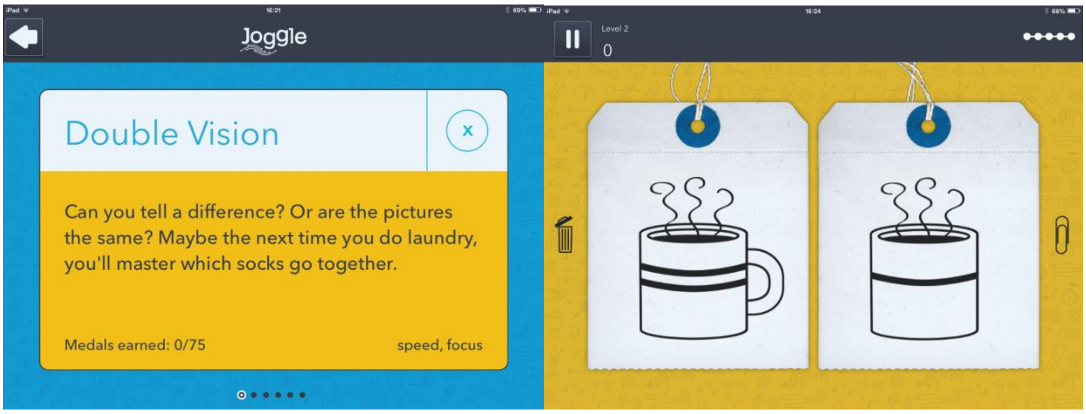

Figure 22. Attention game from Joggle Brain Training

Another popular game in the Apple and Google Play stores was a version of the Stroop test (Stroop, 1935). The Stroop test is a measure of divided attention (a process which requires the user to actively attend to two stimuli at the same time). In the Stroop test, the user is presented with a series of names of colours which are written in a different colour from the written name of the colour. E.g. the word ‘red’ written in the colour orange (see example from Brain Booster Exercises (The Really Useful Information Company LLC., 2014) in Figure 23 below). The user must attend to both stimuli and click the name of the word, rather than the colour it is presented in.

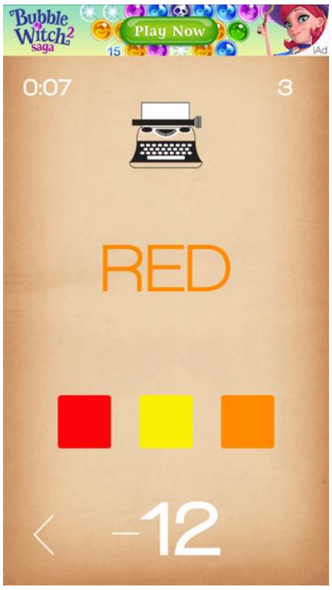

Figure 23. Stroop test in Brain Booster Exercises

7.2.4 Language

Cognitive language games largely fit in the category of verbal reasoning. Train Your Brain- Verbal Reasoning (Webrich Software Ltd., 2014) offers a series of tasks covering language fluency and comprehension. E.g. a word matching mini game where the player is asked to match the two words from two sets that are closest in meaning, see (Set 1: relax, accept, *console*, Set 2: sadden, subdue, *comfort, see* Figure 24). Other tests of verbal reasoning include completing patterns of word pairs and identifying compound words. Verbal reasoning and language tests may be difficult to implement in DOREMI due to Italian and English speaking participants.

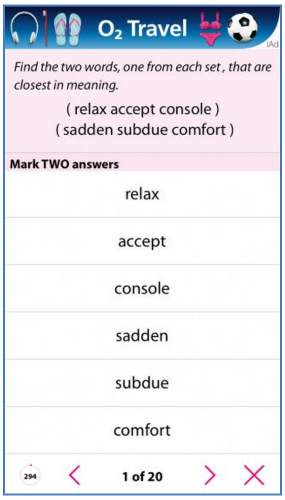

Figure 24. Verbal reasoning task from Train Your Brain-Verbal Reasoning

7.2.5 Calculation

Calculation skills were targeted by games which required quick mathematical skills. Some games e.g. Lumosity (Lumos Labs Inc., 2014) asked the user to quickly decide which of two maths problem results in the larger outcome. E.g, "What is bigger 34- 11 or 7 x 3?". An alternative is to provide algebraic equations and ask the user to fill in the missing numbers e.g. Simple Mind Games (Lake, 2013), in Figure 25. These kinds of games are easy to increase in difficulty by increasing the size of the numbers. Other games also required mental arithmetic but avoided the use of maths problems on screen. Mind: Brain Training (Guerilla Tea Games Ltd., 2014) has a mini game which involves a series of squares appearing on a blank grid. The user must count the number of squares that flash in total and is then presented with a series of three options to choose form to indicate how many squares they counted.

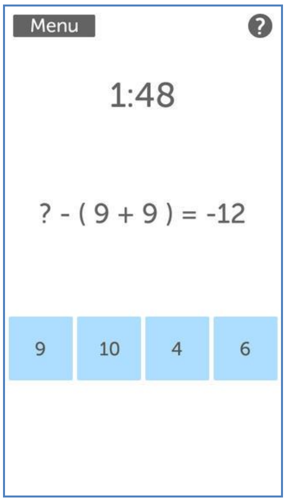

Figure 25. Algebraic problems in Simple Mind Games

7.2.6 Cognitive training packages

Cognitive training packages involve a combination of any of the types of games presented above, utilising the gamification techniques outlined in section 5.1.4 to increase engagement. Some of the better packages will be reviewed here. Training packages comprised anything between 2 and 50 mini games which were either presented as a structured package of games to be played each day (Lumos Labs Inc., 2014), recommended daily games with an option to skip the game (Joggle Research, 2014; Rosetta Stone Canada Inc., 2014), or a free play option where the user can decide which games to play (BASIS Science INC, 2014; Chillingo Ltd., 2014; Digital Artifacts LLC., 2014; Posit Science., 2009). A typical characteristic of these games is the use of push notifications to the smartphone or tablet in order to remind the user to play (see Figure 26).

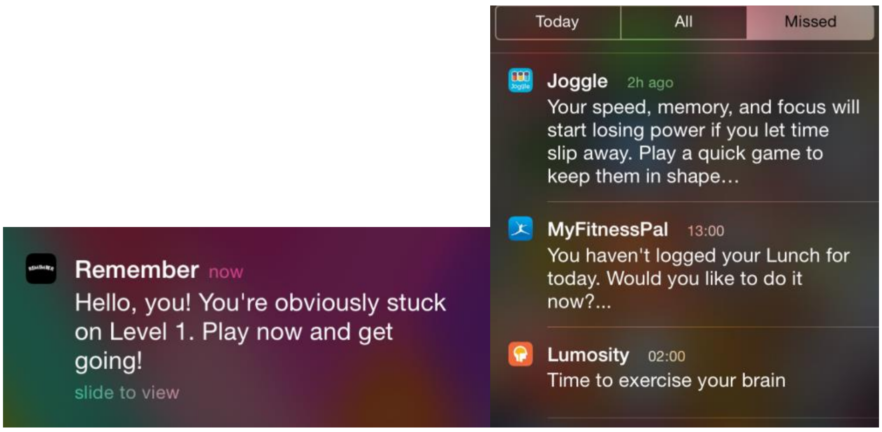

Figure 26. Push-reminders on a smartphone

Cognitive training packages will also typically employ some kind of overall gamified feedback on cognitive performance. In the Dr Kawashima series (Nintendo, 2006), this is presented as a 'brain age' which reduces as performance on the game increases. Joggle (Joggle Research, 2014) utilises an energy system, with progress in the areas of speed, memory and focus demonstrated on a home screen as increases in battery power. Are you a Dodo? (Chillingo Ltd., 2014) presents feedback in terms of progression from an amoeba (indicating poor brain function) through various evolutionary stages of intelligence. Lumosity (Lumos Labs Inc., 2014) gives feedback in terms of a points system, the Lumosity Perfomance Index, which provides scores for speed, memory, attention, problem solving and flexibility, as well as an overall performance score. It is not possible to indicate which type of overall feedback is the most effective, however potential suggestions will be discussed later in Section 8.

7.2.7 Cognitive training aimed specifically at the target market

Of the games located, only Lively Silver (Activate Interactive Pte Ltd., 2013)and Brainy App (Alzheimers Australia., 2013) were aimed specifically at older users (although we accept the possibility that some non-commercially available games may have been developed which were not located by our search strategy). Lively Silver is designed for people with dementia rather than mild cognitive impairment and involved tasks of daily living such as flagging down an appropriately numbered bus or crossing the road at an appropriate time. Whilst this game could potentially be a useful system for older users with more severe cognitive impairments, it would be too simplified for people with mild cognitive impairment and may not be challenging enough to produce changes in cognitive function. Brainy App was designed by Alzheimer's Australia and the Bupa Health Foundation to raise awareness of Alzheimer's and to provide brain training activities as a preventative measure against neurodegenerative disease. Brainy App is largely an educational app offering two brain games (one targeting visuo-spatial ability and the other targeting language). Neither game is intuitive to use and important areas of cognitive function (memory, attention) are overlooked.

7.3 Market research on gamification of exercise and nutrition

Public health initiatives with gamified exercise and weight loss activities have been an up and coming trend for several years. Many existing gamified exercise programs located by our search also incorporated nutritional monitoring, and vice versa. A successful example of a gamified public health programme is "This city is going on a diet", an initiative run in 2007 in Oklahoma City with the aim to collectively lose one million pounds in weight (Cornett, 2014). To track weight loss, users were given access to an online health journal with which to track their weight, activity and nutrition. Users could discuss their progress and activities in a social forum. With smartphones and tablets more ubiquitous than ever, the majority of gamified exercise programs are delivered via an app, providing feedback for self-report exercise activities, electronically recorded exercise or both.

The key characteristics of a gamified exercise and/or nutrition programme include; *tracking; achievements; goals; challenges; social interaction; allowances* and *visual progression*. These features are outlined below in more detail:

7.3.1 Tracking

Apps such as Nike+ Running (Nike, 2014) and MyFitnessPal (MyFitnessPal LLC., 2014) utilise both self-report systems for indicating milestones e.g. exercise completed, distance ran, and electronic exercise trackers for increased accuracy e.g. pedometer, accelerometer. In the screenshots from MyFitnessPal below (Figure

27), users can enter the exercise they have completed, the intensity of the exercise and the duration. Calories burned are based upon the individual's current weight which is stored by the app. For higher accuracy and automatic tracking, the user could opt to sync their MyFitnessPal app with an activity tracker, such as the Fitbit.

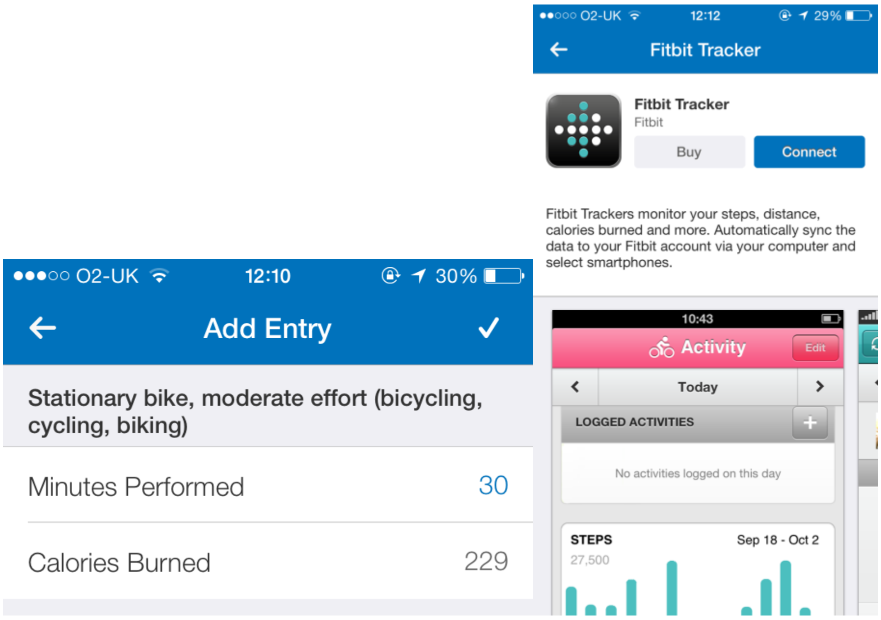

Figure 27. Types of exercise tracking in MyFitnessPal

Cardiovascular exercise lends itself more typically to the use of an electronic exercise tracker, typically worn around the wrist e.g. Jawbone, Nike Fuel Band, Fitbit, or inside the shoe e.g. Nike + Sensor, which feeds back to the gamified interface, wirelessly or via USB cable. For strength exercises which cannot be accurately detected using an accelerometer device, self-report 'tick box' type tracking is more suitable. A key example of this is the series of 30 day challenge series (30 Day Fitness Challenges., 2014), which use small achievable strength exercise goals to build up to a final challenge at the end of the 30 days. Typically these challenges target one body area, e.g. 30 day abs challenge, 30 day squat challenge, and require a daily commitment to an increasing number of repetitions of 4 exercises.

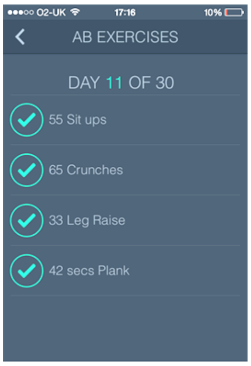

Figure 28. Self report tracking of strength exercises

Calorie consumption is also self-reported in many of the apps offering nutritional monitoring. Apps such as Noom-Weight (Noom Inc., 2014) contain an extensive database of foods, allowing the user to track daily calorie consumption (see Figure 29). Reinforcement is provided for eating below a set calorie target.

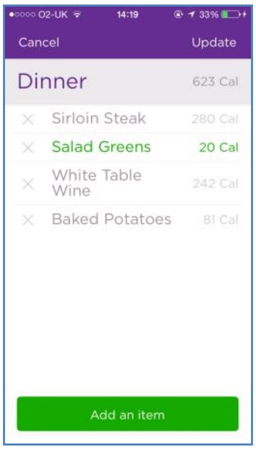

Figure 29. Food and Calorie tracking in Noom-Weight

As well as calorie tracking, some apps, e.g. Cron-O-Meter (BigCrunch Consulting Ltd., 2014) allow the user to see a nutritional breakdown of foods consumed, identifying over or under-consumption of fat, protein, sugar, etc.

7.3.2 Achievements

In computer games, achievements are typically used to encourage players to work towards goals outside of the games scope, to increase longevity and create status among players in a similar way to leader boards. These principles are applied in gamified exercise by providing visual representations of success, e.g. badges, which can be seen by others in the social network. An example of an exercise achievement would be completion of 500 repetitions of an exercise within a week, where the overall aim is to lower the user's weight. An example of an achievement badge from the Fitocracy app (Fitocracy, 2014) is shown in Figure 30.

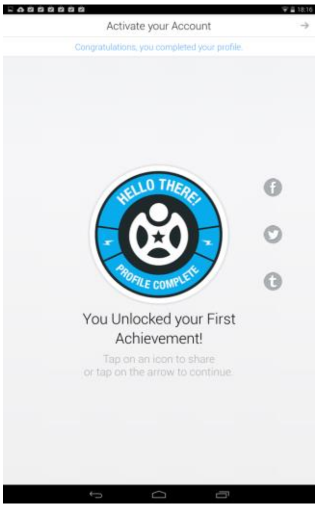

Figure 30. An achievement badge from Fitocracy

In some applications, achievements were led by individual goal setting. Personal goals can be used to give control to the user. Advice can then by tailored to the user in how to achieve those goals. If the user is asked to give a justification for the goal, it can be used to remind the user why they are attempting it in the first place. Figure 31 shows the personal target setting screen from the My Diet Coach- Weight Loss app (InspiredApps (A.L) LTD, 2014).

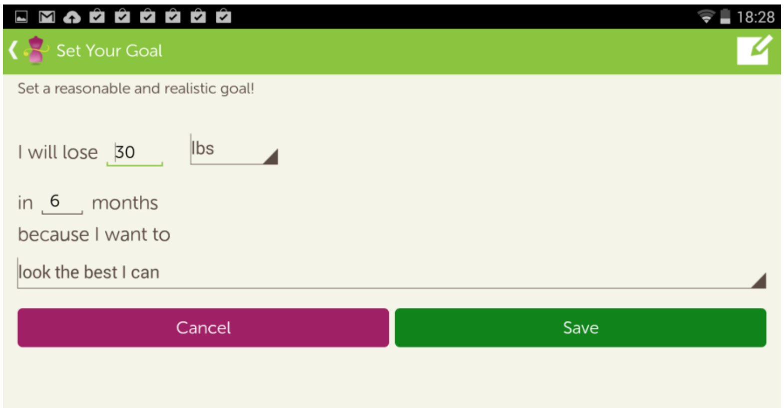

Figure 31. Personal goal setting from My Diet Coach

7.3.3 Goals

Daily goals in computer games are used to prompt users to make the game a part of their daily routine. For the users daily goals break down larger challenges into smaller, easier to manage targets, providing a mastery opportunity. The 30 day challenges described previously are a good example of gamified daily exercises goals. The Nike+ Fuelband (Nike Inc., 2014) uses a visual display of daily goal achievement. The user wears an accelerometer around their wrist which monitors their activity. The accelerometer has an LED display which turns from red to green as exercise is completed. The aim is to achieve green lights on the LED display daily in order to meet exercise goals. This can be synced to a mobile phone or computer to track progress over time.

Figure 32. Nike Fuelband Image from Nike.com

7.3.4 Challenges

Challenges can be directed be either programme or user-generated. The example of a mini-challenge from the Noom-Weight app (Noom Inc., 2014) below indicates a programme-generated challenge requesting that the user eats at least 50% green foods at their next meal. On socially orientated exercise or nutrition platforms, the user can generate and propose challenges to other users. For example, earlier in this report (5.1.4.2, Figure 3) a user challenges others to be the first to run 100 miles.

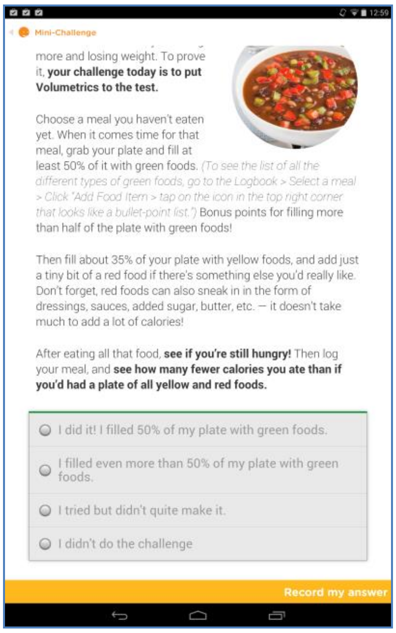

Figure 33. Nutritional challenge in Noom-Weight

7.3.5 Social interaction

In a review of the best weight loss apps for Apple and Android, the highest rated incorporated some element of social interaction, such as forums, wall posting and challenges (Healthline., 2014). One of the largest gamified exercise social networks is Fitocracy (Fitocracy, 2014), which has over 1 million users worldwide. Fitocracy can be accessed via an app or website and provides information ranging from how to properly perform an exercise, exercise routines for different body types and nutritional guidance. As exercise is completed and milestones are achieved, the user "levels up" and earns achievements which are visible to others in the social network. The inclusion of social media into exercise routines allows for support and encouragement from participants. Fitocracy encourages the development of exercise teams with communal goals, which creates a feeling of being part of something larger than the individual. Figure 34 shows a post to a users profile page on Fitocracy allowing other users to see and comment on the activities undertaken.

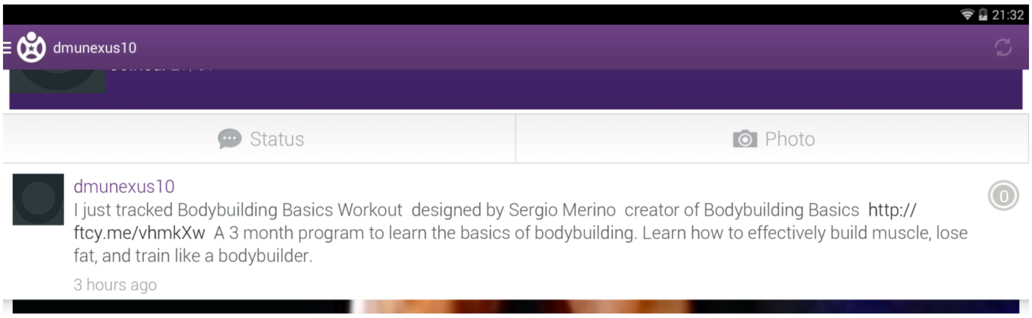

Figure 34. Social post of exercise achievement using Fitocracy

Allowances

In some habit changing gamification users are given "allowances". These allowances are incentives to achieve particular goals. An example of this can be seen in Figure 35 from HabitRPG (HabitRPG., 2014), where a user gains a currency of "Gold" for doing positive activities, which can then be "spent" to allow the user to do enjoyable but not necessarily healthy activities, such as eating ice cream.

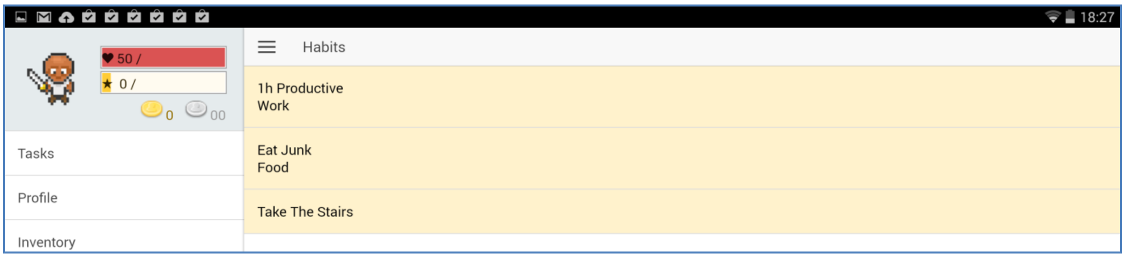

Figure 35. Allowances shown in Habit RPG

Nutritional allowances can also be offered as a reward for completing exercise. In the Noom-Weight app (Noom Inc., 2014), meaning is given to the calories burned by exercise by displaying the equivalent amount of food that the exercise has consumed (see Figure 36).

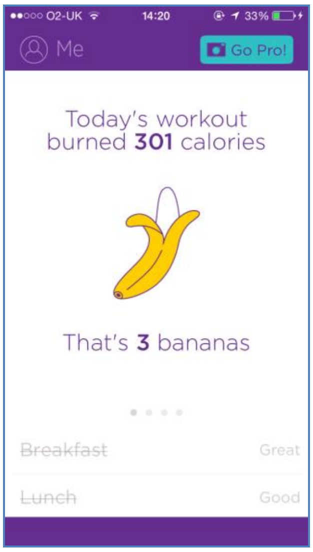

Figure 36. Food equivalents of calories burned in the Noom-Weight app

Visual progression

Progress charts are a good way of improving motivation in individuals and they make it easy to point out progress and patterns in weight, nutrition, exercise frequency or whatever is being tracked. Figure 37 from MyFitnessPal demonstrates weight tracking over time. Progress charts however can also be demotivating if there is lapse in progress.

Figure 37. Weight progress tracking in MyFitnessPal

7.3.6 Gamification specifically aimed at target audience

To our knowledge, there are no examples of gamified exercise and nutrition aimed specifically at the DOREMI target population. Nutrition apps were largely focused on weight loss rather than following a plan for better nutrition. That said, the listed examples provide a strong basis for development of gamified environments for the DOREMI target audience by modifying the gamification principles to be age appropriate. Existing gamified environments for exercise and nutrition may not match the abilities, needs and motivations of older people.

7.4 Market research on gamification of social interactions

Gamification aims at pushing users to become more active, and it is widely diffuse in commercial products. As was mentioned in Table 4 in Section 6.3.6 and on the basis of the work of Werbach and Hunter (2012) and Zichermann & Cunningham (2011) the most common mechanisms used in gamification are:

- **Points:** users are given points whenever they accomplish something the system is trying to encourage them to do. Points keep score, provide immediate feedback, create a sense of progression and provide valuable data for game designers.
- **Badges**: Werbach & Hunter (2012) define badges, sometimes called achievements: as a "chunkier version of points", and Zichermann & Cunningham (2011) describe them as a "visual points systems". They are a visual representation of a specific accomplishment within a gamified system.
- **Leaderboards**: they allow users to see where they stand relative to each other. Both Werbach (2012) and Zichermann (2011) warn about their use: while they can incredibly motivating, providing a user with a goal to accomplish, they can also demotivating, causing users who are very behind from the top to stop using the system.

Werback & Hunter (2012) dubbed the above three mechanism the PBL (Point, Badges and Leaderboards) trial, as they are so common that they are found in most, if not in all, gamified systems. Antin & Churchill (2011) report that such mechanisms made a key element in “gamifying” online social media experiences. Badges are widely used in social systems such as Foursquare, Stackverflow and Wikipedia as a way of engaging and motivating users. Zuckermann & Gal-Oz (2014) confirms that “virtual rewards” (points and badges) and “social comparison” (leaderboards) are two game elements for social interaction. This latter work has a similar scope as DOREMI, as it aims at demonstrate with quantified and continuous measures how the virtual reward and social comparisons are effective in achieving significantly increased walking time over baseline levels.

However, as discussed in several papers (Antin & Churchill, 2011; Kelle, Klemke, & Specht, 2013; Zuckermann & Gal-Oz, 2014) “virtual rewards” and “social comparison”, *per se*, are not enough to produce social engagement and enhance motivation. To this end the following five functions would be considered in constructing a powerful gamified tool for social interaction:

- **Goal settings**. It aims to challenge users to meet the mark set for them. Goal setting is an effective motivator, and experimental studies have illustrated that the most motivating goals are those that are just out of comfortable reach (Ling, Beenen, Wang et al, 2005). Moreover, goal setting is most active when users can see their progress towards the goal (Fox & Hoffman, 2002). Without signpoints to mark the way, there is little or no feedback to keep users moving in the right direction. In the DOREMI case this would be implemented on the bases of the degree of adherence with the prescription of both the diet regime and the physical exercise assigned to the older person (see also Deliverable 2.2). A signpoint based on a virtual rewarding system would measure the progress achieved by the users (see also the function related to “status/affirmation”).

- **Instructions.** They aims at provide users about what type of activity are possible within a given system (Montola, Nummenmaa, Lucero, Boberg & Korhonen, 2009). This function not only instructs new users but also for helps siloed users diversify their participation. Examples of the type of activities and interactions that are highly valued (Kriplean, Beschastnikh, and McDonald, 2008) can be given, and in so doing provide a kind of social shaping of the user activities. Users come to understand individual valued activities and can also gain understanding of the community of the users. In the case of DOREMI they represent the engagement rule set up for using the system by the user community.

- **Reputation.** It provides the basis on which reputation assessment can be made. The possibility to examine the reputation of another user can provide a summary of interest and engagement levels, for example indicating whether a user is deeply or weakly engaged in the social community (Pujari, 2006). In the case of DOREMI, reputational mechanisms can be based on the interest of the user in perceiving the goal setting and in the frequency of his/her interaction (virtual and physical) with the other community members as well as the number of friendships and preferences that he/she made from the community members and from outside (in this regards see the rules defined in Deliverable 2.2 in relation to the measurement of the degree of virtual and physical relationships of an individual).

- **Status/affirmation.** It represents the achievements of the user of the system and communicates past accomplishment. Notably, the power of status rewards derives from the expectations that others will look more favourably upon someone who has undertaken the task assigned by the system (Antin & Churchill, 2011). It also provides personal affirmation to serve as reminders of past achievements and marking milestones. It also allows the establishing of competition amongst community participants based on the achieved level of status/affirmation. In the case of DOREMI this would be implemented on the bases of the degree of fulfilment of the goal settings (see the first bullet point above) with a scoring system that increase/decrease the status according to the degree of achievement of the defined goals (in this regards see also Deliverable 2.2).

- **Group identification.** It aims at defining the shared activities that bind users together around shared experiences. It can provide a sense of solidarity and increase positive group identification through the perception of similarity between an individual and the group. This type of group identification is valuable in social media because increased group identification promotes increased cooperation in collaborative situations. In the case of the DOREMI project this function is important to support the constituency of cluster of users (e.g. the ones only interested to the physical exercises and that could find in the social gamified environment the opportunity to share this common interest with persons with similar characteristics, or opposite individuals only interested in on-line games who want to stay in contact with persons with the same interest).

Below are examples of gamified tools supporting social interaction that are available on the market. The closest examples to the DOREMI concepts have been discussed, considering gamified tools for social interaction that target the adult population.

Some examples of such tools have been already discussed in the previous paragraphs:

- **Foursquare.** Foursquare is a location-based service in which people can earn points, badges and achievements by sharing their location. Earning these status symbols is done by 'checking in' with the Foursquare application on a certain location. When a user has the most 'check ins' on a certain location, he or she will receive a special status for that location, effectively competing with the others. Foursquare has a community of over 30 million people. The predecessor of Foursquare called Dodgeball had issues with keeping people engaged and making it a habit for them to 'check in' which Foursquare addressed through gamification.

- **Nike+.** Nike+ is hardware which measures and tracks user activity. Nike+ users can see what their performance is on a certain day and share these results with others. Others can react on these results by challenging and trying to beat them, for example, run a greater distance than the other.

However, these examples are based on the rewarding systems and lack of some of two of the five basic function of social interaction discussed above. In particular they are not based on reputation and group identification that are two of the distinctive functions characterizing social interaction. On the contrary, examples of gamified tools that consider all the five social interaction functions are:

<u>Reading Challenges</u>

The Reading Challenge platform is a highly engaging gaming framework for encouraging and supporting adults with low literacy to develop and improve their reading skills. It is an online and mobile app that turns the "Six Book Reading Challenge" diary into a social experience where players use physical or online books in order to participate. Challenges are personal or communal, encouraging the participation of a community of users by creating a sense of support and allowing the users to feel socially connected with each other.

Figure 38. Reading challenges tool of http://playgen.com/play/reading-challenge/

Connect me

_connectMe is a highly adaptable network visualisation and discovery tool that encourages users to find and connect with other people who share similar interests. _connectMe is an engaging playful tool utilizing the power of gaming mechanisms, and is able to leverage motivations between the network and its users. It also introduces and displays new types of statistics, acting as a more informative and interactive way to navigate through the _connect network. The app is delivered simultaneously through multiple channels including desktop, web, ipad iOS and Android tablets and PlayBook.

Figure 39. Connect me tool of http://playgen.com/play/_connectme/

Daily Challenges

Daily Challenge is a social well-being experience that allows users to improve their health in one small way each day. Users complete simple challenges and share the experience with those closest to them. At the same time users earn points, reach new levels, and get support from the Daily Challenge community.

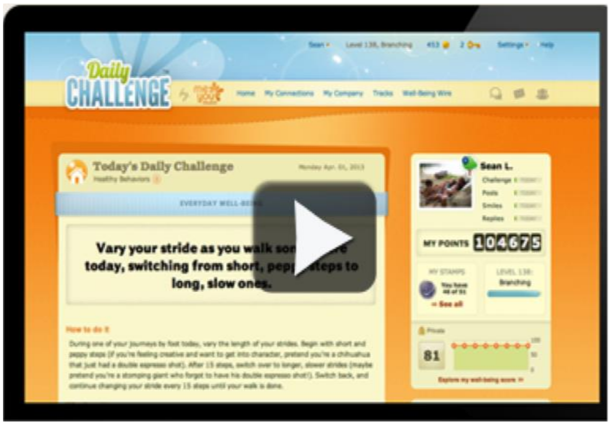

Figure 40. Daily Challenge tool of http://meyouhealth.com/daily-challenge/

Walkadoo

Walkadoo is a pedometer-based program that introduces people to a realistic and convenient way to add more movement to their day. It utilizes the latest game dynamics, mechanics, and aesthetics to power social interaction that extends and sustains engagement.

Figure 41. Walkadoo tool of http://meyouhealth.com/walkadoo/

Hello 200

Two hundred is the number of daily calories the average person needs to cut to maintain a healthier weight. Hello 200, a mobile-focused weight management product from MeYou Health with a community of people dropping their 200 calories daily. Each morning, Hello 200 sends simple suggestions on how to find and cut 200 calories and still eat well. Members can share their daily 200 and connect with the community via tips, success stories, and celebration moments. Completing these activities builds healthy eating habits, one choice at a time.

Figure 42. Hello200 tool of http://meyouhealth.com/hello200/

Well Being Tracker

Well-Being Tracker™ (WBT) is a way to measure and improve well-being. It's based on the Well-Being 5 (WB5) assessment, developed by Healthways and Gallup. The WB5 is the product of over a decade of continuous, published research, and it covers the five domains of well-being: Physical, Career, Social, Financial, and Community. Well-Being Tracker creates an interactive experience for users to measure these five domains and then explore their results.

Figure 43. Well Being Tracker tool of http://meyouhealth.com/well-being-tracker/

HealthMonth

HealthMonth is a monthly game that is all about making small improvements to health, one month at a time. HealthMonth helps individuals to take the science of nutrition and behaviour change and combine it with social gaming tools. Players pick one or more rules from the menu of dietary, fitness, relationship, mental health and financial health behaviours, or design their own rules to follow for a month.

Figure 44. HealthMonth tool of http://www.fitbit.com/apps/healthmonth

SparkPeople

SparkPeople provides a fun, supportive environment that encourages people to live life without limits by setting positive, attainable goals that support lifestyle behavioural changes. By simply creating a SparkPeople member profile individuals can take advantage of nutrition and fitness tracking systems, which allow members to dynamically link data tracked and to engage with the community.

Figure 45. SparkPeople tool of http://www.fitbit.com/apps/sparkpeople

7.5 How will the DOREMI system present something new to the market?

No product was identified which could provide a holistic system to promote active ageing in people with mild cognitive impairment. In terms of the cognitive training games, nothing was located which had been developed for older people with mild cognitive impairment, taking the specific needs of this population into consideration. DOREMI will utilise the user profile characteristics outlined in Section 6, along with user-centred design activities (Section 6.3) to develop cognitive training games with appropriate level of challenge, engaging design and meaningful gamification in order to encourage participation. DOREMI cognitive training games will be evidence based, using adaptations of existing neuropsychological tests know to be sensitive to particular cognition domains. The developed games will be designed to minimise computer anxiety or feelings that the system is too technical or complicated. For example games based on neuropsychological tests will not be known be known by their official test name, e.g. a game based upon the Stroop test could be called 'word colour mismatch'.

Many examples of gamified exercise, nutrition and social interaction were identified but none designed specifically for older people. Exercise gamification in DOREMI will follow appropriate guidelines for an older population, as outlined by the World Health Organisation (WHO, 2010), incorporating both strength and cardiovascular exercises. Existing nutrition and exercise applications largely focused on weight loss, which may not be the most appropriate outcome for many DOREMI users. Many older people suffer from poor nutrition and fitness levels (in addition to being under or overweight). The DOREMI system will reward positive nutritional changes, not simply calories consumed or weight lost. Although holistic systems exist which monitor and gamify multiple domains such as sleep, exercise and nutrition e.g BASIS Science Inc. (2014), Jawbone (2014), none targeted the active ageing domains which will be covered in DOREMI. The DOREMI system will provide a holistic system which promotes exercise, good nutrition, cognitive training and social interaction.

Appropriate gamification tools will be designed specifically for the DOREMI target market as a result of user-centred design activities. As mentioned previously, research suggests that people find gamification useful and effective at any age, but more difficult to use as they get older (Koivisto & Hamari, 2014). The ethos of active ageing is to optimise opportunities for older people to participate in health and social activities. To our knowledge, no gamified system exists which has been developed using these principles to promote social inclusion and cognitive, nutritional and physical functioning.

8. GAMIFYING ACTIVE AGEING PROTOCOLS

8.1 Modelling active ageing protocols

Active ageing protocols will determine a schedule requiring the daily completion of nutrition, cognition, physical and social activities. Figure 46 demonstrates the daily activities related to the active ageing protocols

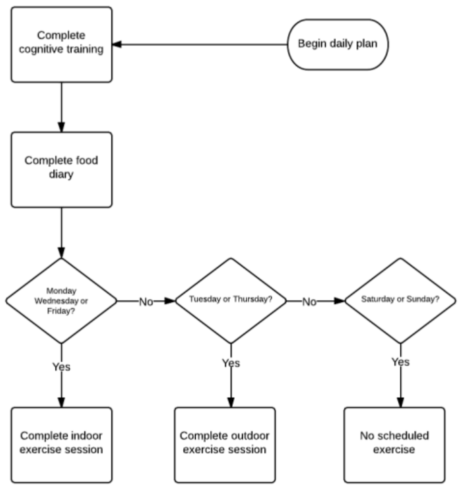

Figure 46. Daily DOREMI activities

<u>8.1.1 Decomposition of gamification devices.</u>

In this section, we develop further the description of the process of gamifying the activities associated with the collection of active ageing protocols introduced earlier.

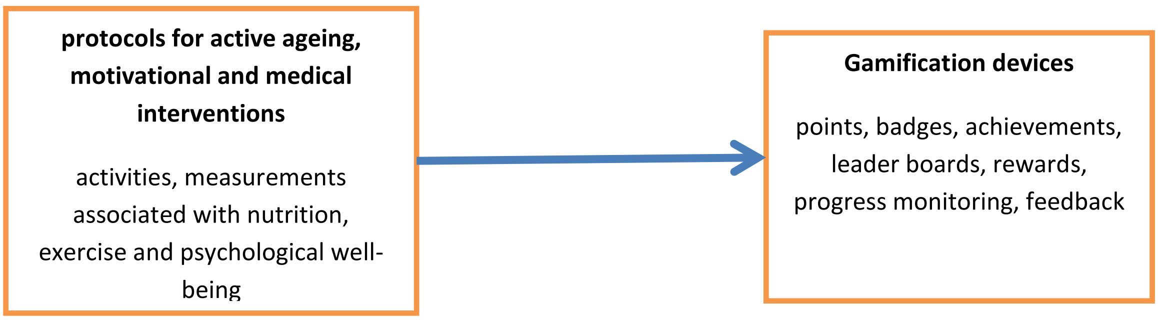

Figure 47. Gamifying active ageing protocols

First, the notion of ‘gamification device’ will be examined and structured to enable better opportunity for mapping activities and measurements to these. Hamari & Eranti, (2011) provide a framework for designing and evaluating ‘achievements’ and ‘rewards’. They consider that achievements are surprisingly consistent across games, and have three keys components: signifying elements; completion logics, and rewards.

A *signifying element* contains information for the player and comprises a *name*, a *visual badge* and a *description*. The name identifies the achievement; the visual badge is a graphic that will appear possibly on the player's sign-in page. The badge may appear in an unachieved state, typically greyed out or in an achieved state, typically in full colour. The description is what needs to be done, or what has been done to acquire the particular achievement, for example checking into 5 different branches of the same coffee shop chain.

The achievement also has a *completion logic*, which comprises a *trigger*, one or more *conditions*, and a *multiplier*. The trigger is an action or event, either player generated or system (or game) generated required to obtain the achievement, such as checking in on Foursquare or having a review accepted on TripAdvisor. The conditions describe requirements or limitations on the trigger, such as not having checked into the same location previously on Foursquare. The multiplier is the number of times the trigger is required to obtain the achievement, at least 1 or 5 in the example given above.

The *reward* is the consequence of the achievement for the player, and falls into 3 categories: an *in-game* reward, an *achievement game* reward, or an *out-game* reward. The in-game reward may be an additional advantage (say, an ability or power) that the player can use in playing a game from that point forward. Another example could be some form of in-game finance. There may also be a separate game based around acquiring rewards, leading to the idea of *meta-achievements*. An example here could be collectables, where each reward is a picture provided by the system related to a common theme that the player adds to a personal album. These collectables could be swapped between participants or players if the player has a duplicate of a picture. The out-game reward maybe a free cup of coffee, collected by the player from the coffee shop in exchange for some electronic reward token.

Figure 48. Expansion of the process of gamification of active ageing protocols

The process of mapping from activities associated with active ageing protocols to gamification devices will consider the individual components of an achievement and the application of the design guidelines described in Section 5.

8.1.2 Structure of activities

Considering now the activities associated with the cognitive functioning, exercise and nutrition, collectively these represent candidate triggers for achievements, these can be broadly split into 2 categories, activities related to a game within the DOREMI system, and real-world activities where the results of these will be gamified. At present, it is only the protocols dealing with cognitive functioning that will have actual games developed for them within DOREMI. The other parts, exercise and nutrition, will have a program of real-world activities designed around the needs of the individual by a trainer and a nutritionist respectively

Table 6. Types of activities associated with DOREMI active ageing protocols

Game activities *cognitive training:* activities associated with performance on specific games testing short term and working memory, visuo-spatial skills, attention, reaction time • unit activities completed in a given time , e.g. calculations • complexity of unit activity completed, e.g. size of matrix of items in memory recall test • speed of completing unit activity e.g. reaction time test • units completed towards personal target e.g. Lumosity personal plan
Real-world activities *exercise:* activities associated with personal training plan • time spent in different types of in-door and out-door exercise activities at each of the 3 levels dictated by the protocol, • duration of exercise • intensity of exercise • calories consumed during exercise, *nutrition*: metrics associated with daily food intake as monitored by external nutrition monitoring software and the plans suggested by the nutritionist • closeness of food intake to that proposed as a target • calories consumed per day, • progress towards target weight

The significance of this distinction is that memory prompts about the achievement can be integrated with the activity itself in the case of cognitive games. With the diet capture software, there exists potential for a DOREMI wrapper that could include the status and prompts related to the achievements. This will be more difficult to achieve in the case of exercise activities. Here the participant will have to remember the association between the activity while it is being performed and the achievement.

8.1.3 Mapping between activities and achievements

The guidance provided in this section is intended as a template for achievement design. The achievements may be designed around the full set of activities to form a coherent scheme that takes the design requirements for the older user group into account. The selection of actual achievements for triggers, the conditions and the multipliers appropriate for each achievement will be deferred to later tasks within the Work Package. Importantly, these will be informed by the outcomes of the focus groups, currently in progress.

Furthermore, the meta-achievements scheme may be directed towards accommodating the individual interests of the participant in the case for example that a set of collectables is used.

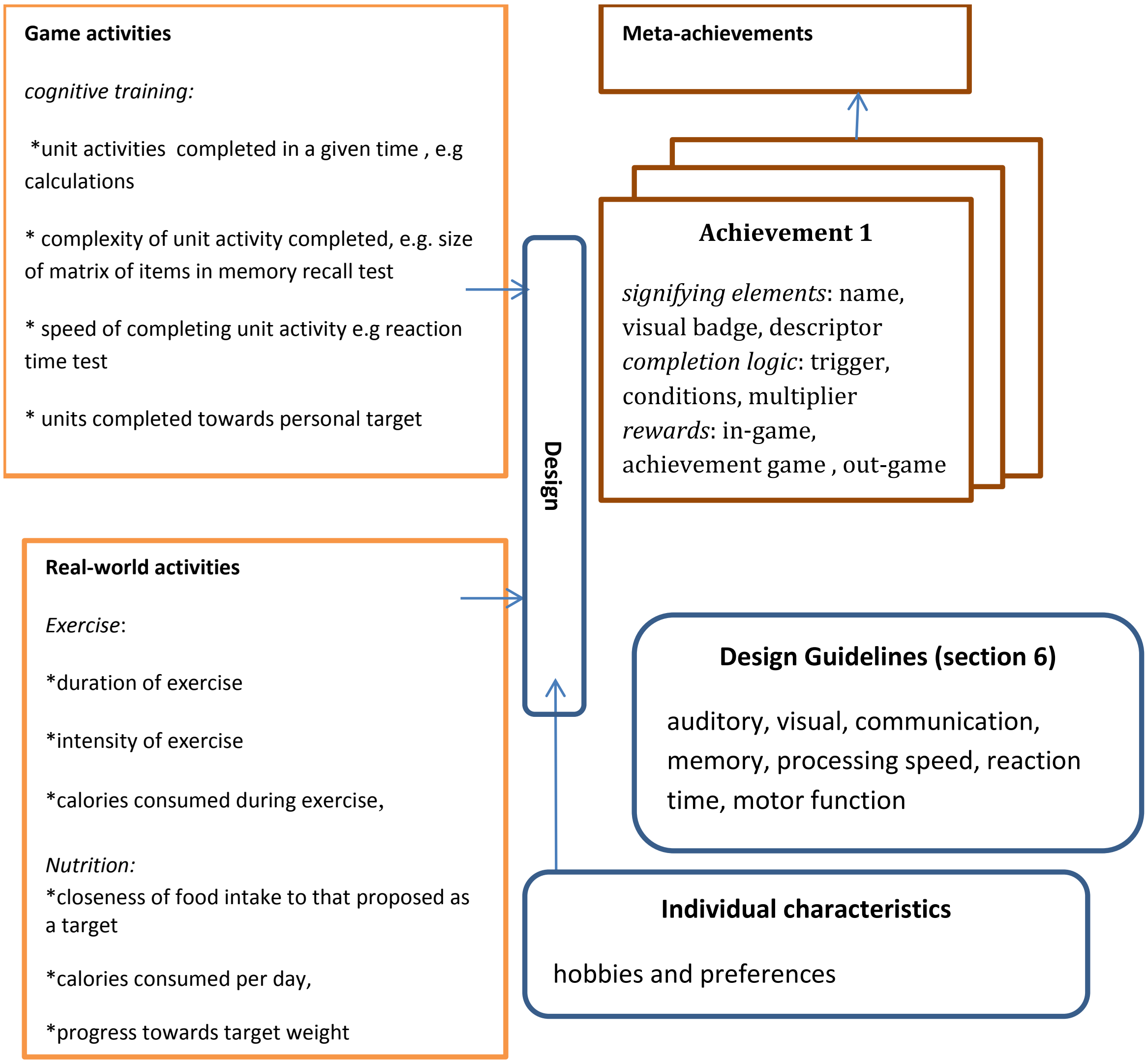

Figure 49. The association between activities, achievements and design guidelines

8.1.4 Inclusion of social activities

This is envisaged currently at 2 levels. Achievements may be individually based or team based. Progress made by an individual contributes to the overall progress of the team. For example, the distance walked by individual members of a team may result in an achievement for all team members. This may be accompanied by leader boards of top contributors to the team performance.

The second level is via the meta-achievement system where activities associated with this may be designed specifically to promote social interaction with others, such as the trading of pictures in a system of collectables.

8.2 Towards a design solution for a gamified active ageing environment

8.2.1 Aggregated feedback (overall-gamified environment)

As well as the gamification of each individual active ageing protocol, it is proposed that participation in any of the DOREMI protocols (exercise, nutrition, cognition and social interaction) will result in a visual display of progression on the DOREMI home screen. This visual display will demonstrate the sum of the aggregated points earned by participants for completing any of the individual protocols. See Figure 50.

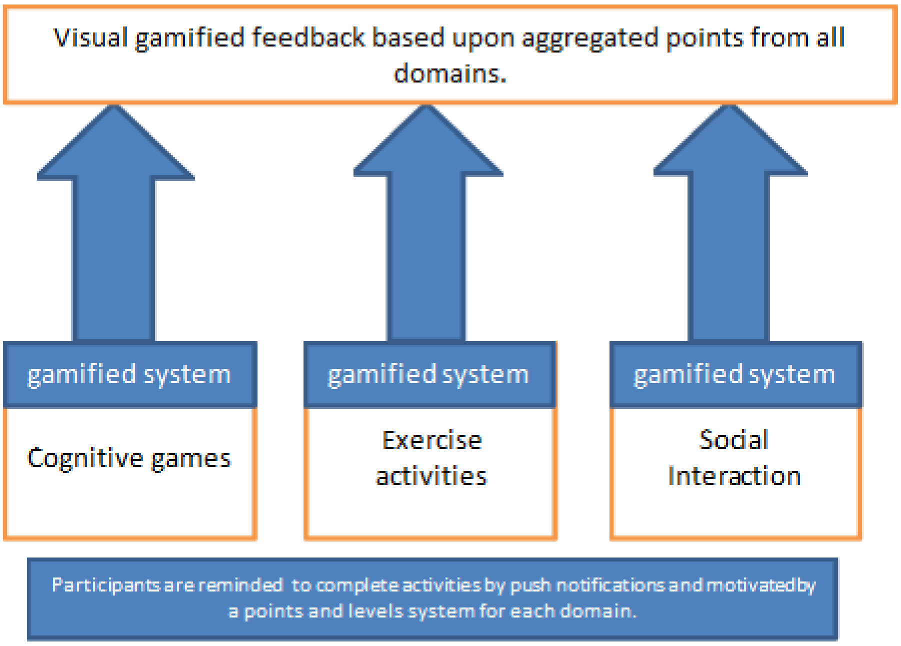

Figure 50. DOREMI two-tier gamification system

The theme of this progression screen will be determined by the user centred design activities in order to make it relevant and engaging to older users with mild cognitive impairment.

There are a few different approaches to delivery of the overall gamified environment. These include, but are not limited to, the examples below:

- *Graphical representation*. E.g. a barometer, a graph or an energy system. Overall progression from completion of DOREMI activities is visualised by increasing mercury in a barometer. The aim is to reach the top of the barometer.

- *A race*. This is an extension of the graphical representation. Users could be assigned an avatar on screen which is part of a race e.g. boats in a race along a river. Progression with DOREMI tasks will move the boat along the river. The aim is to get the boat to the finish line.

- *A collection of badges*. E.g. users could achieve a badge or sticker to add to a collection for reaching particular scores/achievements. This could be themed e.g. photographs of international landmarks or wildlife. The aim is to fill the collection of badges.

- *Evolution of a character*. E.g. users can see visual development of a character on screen which evolves as they complete DOREMI activities. For example, a tadpole which evolves into a frog as the user completes their activities, or a plant growing from seed. The aim is to fully evolve the character.

8.2.2 A preliminary gamified system for DOREMI physical activities

The gamified system for each protocol can be represented as a system of points, levels and visual achievements. In the example below, we will discuss this system in relation to DOREMI exercise activities (the system will be expanded for other DOREMI activities e.g. social and cognitive later in WP5 as the games and social system are developed). Points are largely awarded for quantity of exercise and frequency of engagement with DOREMI exercise activities. Levels are used to gradually increase the challenge of the activities in line with the users' increasing abilities. Visual achievements will be used to provide variable ratio, variable interval reinforcements. Each will be discussed in turn below.

8.2.2.1 Points

A scoring system will be used to provide points for activities relating to each of the DOREMI protocols (social, physical activity and cognition).

Table **7** below shows a points scoring system for exercise activities. These activities relate to exercising with the motivational video, and self-led indoor and outdoor exercises. The way in which these points will be displayed to the user will be dependent on design activities conducted later in WP5 (e.g. a barometer, a graph etc.). Points will be fed into the overall gamified feedback environment which amalgamates scores from participation in any of the DOREMI protocols.

Table 7. Example points system for DOREMI exercise activities

Action	Points
Begin participating in DOREMI exercise activities	One off: 100 points
Watch motivational exercise video (first time)	One off: 25 points
Exercising socially (each time)	10 points per social encounter
Log in to DOREMI exercise activity	5 points per day
Number of minutes of exercise daily	1 point per 10 consecutive minutes
Level 1: Reaching target of 195 minutes per week	50 points

Level 2: Reaching target of 235 minutes per week	75 points
Level 3: Reaching target of 260 minutes per week	100 points
Non completion of weekly target (any level)	-50 points

8.2.2.2 Levels

DOREMI exercise levels have previously been described in D2.2. The primary criteria for each level is minutes of exercise per week as follows; completion of 195 minutes per week (Level One), 235 minutes per week (Level 2), and 260 minutes (Level 3). In addition to completing the required number of exercise minutes, users will be required to complete a number of other challenges (in line with the points for each level outlined in D2.2)

Level 1

The activities in **Table** 8below have been designed to ensure that each user must remain at Level1 for at least two weeks while they get used to the system. These extra levelling requirements mean that even if a person is active in completing 195 minutes per week of exercise when they enter the DOREMI programme, they still have additional challenges in relation to social activities, exercise variety and exercise knowledge. This points system can be revisited and scaled as further DOREMI elements (e.g. personal training, coaching) are designed in WP5.

Table 8. Exercise. Level 1 requirements

Level 1 activity	Measurement technique
195 minutes exercise per week	Measured by wrist sensor
3 indoor sessions per week	Measured by wrist sensor
2 outdoor sessions per week	Measured by wrist sensor
Know advantages of regular physical activity	Correctly answer brief multiple choice question about exercise presented on tablet (something they have learned in training phase)
Regulate aerobic activities	Complete exercise at optimal exertion level at least 70% of the time over two weeks. Measured by accelerometer and heart rate monitor in wrist sensor.
Learn new activities or start old ones again	Possible self-report system on tablet
Learn activities to improve articular mobility and stretching	Watch motivational video (measured by tablet) AND complete at least 4 sessions of

	stretching (measured by sensor)
Learn to lift and move weights	Watch motivational video (measured by tablet) AND complete at least 4 sessions of weights (measured by sensor)
Favour social activities	2 social exercise encounters per week for 2 weeks (measured by wrist sensor)

Level 2

The activities in Table 9 below have been designed to ensure that each user must remain at Level 2 for at least two weeks. The challenges are slightly increased from Level 1.

Table 9. Exercise- Level 2 requirements

Level 2 activity	Measurement technique
235 minutes exercise per week	Measured by wrist sensor
3 indoor sessions per week	Measured by wrist sensor
2 outdoor sessions per week	Measured by wrist sensor
Know advantages of regular physical activity	Correctly answer brief multiple choice question about exercise presented on tablet (something they have learned in training phase)
Daily exercises for balance and articular mobility	Completing the daily protocols at least 5 days per week for 2 weeks
Regulate aerobic activities	Complete exercise at optimal exertion level at least 80% of the time over two weeks. Measured by accelerometer and heart rate monitor in wrist sensor.
Favour social activities	3 social exercise encounters per week for at least 2 weeks (measured by wrist sensor)

Level 3

The activities in Table 10 below have been designed to ensure that each user must remain at Level 3 for at least three weeks. The challenges are slightly increased from Level 2.

Table 10. Exercise Level 3 requirements

Level 3 activity	Measurement technique
260 minutes exercise per week	Measured by wrist sensor
3 indoor sessions per week	Measured by wrist sensor
2 outdoor sessions per week	Measured by wrist sensor
Know advantages of regular physical activity	Correctly answer brief multiple choice question about exercise presented on tablet (something they have learned in training phase)
Daily exercises for balance and articular mobility	Completing the daily protocols at least 5 days per week for 3 weeks
Regulate aerobic activities	Complete exercise at optimal exertion level at least 90% of the time over two weeks. Measured by accelerometer and heart rate monitor in wrist sensor.
Favour social activities	4 social exercise encounters per week for at least 3 weeks (measured by wrist sensor)

8.2.2.3 Achievements

In addition to the points and levels system which largely reflects quantity of exercise, achievement rewards can also be provided for social and level milestones. These achievement rewards can be provided at variable intervals in order to encourage sustained engagement with the system (see 5.4. Schedules of Reinforcement). This type of gamified feedback has been shown previously in Figure 41 and can relate to 'Signifying Elements', e.g. awarding a person with the label 'Olympian' when they reach Level 3 of the exercise condition or Rewards, e.g. a social 'badge' on their personal profile after 5 recorded social exercise encounters. Until further user-centred design activities are conducted throughout WP5 it is difficult to make conclusions on the design of a visual rewards system**.** Table 11 below provides some examples of potential visual achievements.

Table 11. Example visual rewards for DOREMI exercise activities.

Action	Badge
Halfway through level one	Novice label on social network
Progressing to level two	Intermediate label on social network
Progressing to level three	Olympian label on social network
Top of the leaderboard	Exercise champion badge on home page

Exercising socially 5 times	Social badge on home page

8.2.2.4 Relationship with aggregated feedback system

The points achieved from the gamified exercise activities will feed into an aggregate score along with social and cognitive activities and visually displayed in the overall gamified feedback system discussed in 8.2.1. Later in WP5, when cognitive and social games are designed, a levels system for the overall feedback environment can be designed. A useful feature of the overall gamified environment is the ability to provide automated reminders to participants to complete a given behaviour. This is particularly salient given the likely memory deficits experienced by people with mild cognitive impairment. Reminders to complete any of the active ageing protocols can be delivered using push notifications directly to the tablet, as shown earlier in Figure 26. A potential problem is that all of the gamification and games protocols require the user to remember to pick up the tablet and engage with the DOREMI activities. If possible, the tablet should have a flashing light or a sound to alert the user to the tablet.

8.2.3 Gamification of cognitive protocols

Cognitive training games will be delivered via the tablet. The cognitive games will need to train the areas of cognition which are evaluated during the neurological assessment carried out pre and post intervention. Although there is some evidence to suggest that training any area of brain function can have an effect on non-trained areas of cognition (Smith et al., 2009), it is logical to train specific areas of cognition e.g. working memory, with a view to directly assessing the effect of the specific area of training (using the digit span test), in addition to the global measures of cognition measured in DOREMI (MMSE; Folstein, Folstein, & McHugh, 1975, and MoCA; Nasreddine et al., 2005). We cannot simply turn the neuropsychological assessments from baseline testing into games, as any outcome measures obtained at follow up will simply reflect the level of practice at the test, rather than genuine improvements in cognitive functioning. To give an example, the digit span test requires the participant to recall increasingly long strings of numbers. This could be trained in a computer task which asks users to remember the position of an increasing number of squares on a grid, thus training working memory without being a direct replica of the DOREMI study outcome measure for working memory. Many cognitive training games are based on popular neurological assessments as these have been proven to be sensitive in the detection of cognitive impairments. Neurological assessments are typically game-like in nature (many would fit in the' puzzle' game genre) and provide a strong basis for designing appropriate cognitive games. To encourage behaviour, motivational gamification tools will be utilised.

8.2.3.1 Duration and frequency of cognitive training

There is little evidence to support a dose-response relationship between frequency and duration of cognitive training sessions and improvement in cognitive functioning (Li et al., 2011). In their meta-analytic review of cognitive training interventions for people with MCI, Li et al (2011) suggest that training procedures that involve a low number of sessions with long session duration are not optimal for improving cognition (studies with the longest sessions and the longest total intervention duration had smaller effect sizes than the studies with shorter intervention duration). In the absence of a "gold standard" training duration we propose that a pragmatic solution would be to follow the model of Lumosity (Lumos Labs Inc., 2014) and Joggle (Joggle Research, 2014) and require users to engage with a short duration of cognitive training (15-30 minutes) at a high frequency (daily). This could consist of daily selection of games covering the cognitive protocols above. 15-30 minutes per day over 60 days would result in 15-30 hours of cognitive training over the intervention period.

In order to engage people with the cognitive training games, gamification principles will be applied, based upon the results of the user centred design activities. Completion of activities using the tablet will automatically be registered on the DOREMI system so that that appropriate feedback (points, visual progression, badges etc.) can be awarded.

8.2.4 Gamification of nutrition protocols

If nutrition is gamified as part of DOREMI, users could complete their daily food intake via external software on the tablet. The protocol for nutrition activities has already been defined in detail in D2.2. In summary, during the training phase users will submit a daily food diary to the nutritionist. The nutritionist provides daily coaching and a nutritional plan. During the intervention, participants will continue with their daily plan without regular feedback, although support will be provided by the nutritionist on demand. If possible, nutritional monitoring software could be linked with the DOREMI system so that completion of activities can be monitored.

If external nutrition software is not linked to the DOREMI software, it will not be possible to provide integrated feedback. One possibility is to use a tick box system similar to the 30 day fitness challenges (discussed in section 7.4) within DOREMI, where users are asked to press a tick button if they have recorded their food diary for breakfast, lunch and dinner. This way, interaction with external nutrition software could feed in to the overall DOREMI rewards system.

8.3 Behavioural analysis (in the context of Web 2.0 social communities) to inform the gamified protocols

In previous deliverables D2.1 and D2.2 it was discussed how healthy practices for older people implied a direct engagement of the individual in his/her care management. In particular it was explained what were the determinants for health-related behavioural changes driving older people towards a healthier lifestyle that could have as a consequence the positive clinical outcomes discussed in D2.2.

In section 7.4 of this report we discussed on the bases of existing examples how social media and social interaction could be used in gamified tools to engage individuals to reach a predefined and (in some cases) self-reported goal related to lifestyle and well-being. These evidences are also been used in shaping the key characteristics of the social interaction gamification in DOREMI (see sub-paragraph 6.3.5).

Moreover, the market analysis (paragraph 7.4) underlined how many examples of gamified tools addressing exergame and nutrition even when they are designed considering social interaction features don't explicitly target DOREMI population.

Therefore the aim of this section is to define the key elements of the use of social media to promote active ageing and health in older people in a way that can be integrated with cognitive training, exercise and diet monitoring as foreseen in DOREMI. Moreover it will be explored if there are any other techniques that can be used with older people to promote social interaction.

Effectiveness of web-based self-management and personalized health are extensively analysed in literature reviews (Neve, et al., 2010; Samoocha, et al, 2010; McCallum, 2012), however the social interaction aspect of the web-based applications are not well addressed with the exception of more recent studies like the one of Stellefson et al. (2013) which produced the following conclusions on the bases of an extensive literature review of Web 2.0 applications for chronic disease management for older adults: "…*despite several studies report that 65+ aged persons remain strongly connected with offline sources of medical assistance and advice and other explain that internet is irrelevant to them, as they can meet information and communication needs in other ways ad seen no points going on-line…"*, there are other studies showing: "*that Web 2.0 participants felt greater self-efficacy for managing their disease(s) and benefitted from communicating with health care providers and/or website moderators to receive feedback and social support…… Participants noted asynchronous communication tools (eg, email, discussion boards) and progress tracking features (eg, graphical displays of uploaded personal data) as being particularly useful for self-management support…".*

Therefore at the moment the engagement of the older population in such activity is still controversial and it might be the reason why the Web 2.0 market products don't address this segment of population yet.

However, from the literature reviewed the key barriers to a lack engagement of older people in their health care management through social media seem to be more technical (e.g. lack of access to high-speed internet connections and lack of enough digital literacy) rather than behavioural (Stellefson et al., 2013).

Based on the evidences provided by some authors (Oinas-Kukkonen & Harjuma, 2009; Glasgow et al., 2011; McCallan, 2012; Stellefson et al., 2013) that have analysed the engagement of older people with Web 2.0 tools, in **Table 12** we provide a list of the key characteristics that the DOREMI gamified environment would have to maximize the effectiveness in stimulating users in healthier behavioural changes. In particular the table suggests a list of key features related to social media interactions that have been positively experimented in engaging ageing population in healthy lifestyle.

This list of key features is based on the pre-requirement that the users have a minimum level of digital skills as it is the case of DOREMI target population.

Table 12. Characteristics of the Web 2.0 tool to inform gamified protocol in DOREMI

Characteristics of the WEB 2.0 tool to inform gamified protocol in DOREMI	Key features	Note
Primary Task Support	Reduction, Tunnelling, Tailoring, Personalization; Self-Monitoring, Simulation Rehearsal	This are the typology of goal settings that we have discussed in paragraph 7.4
Dialogue Support	Praise, Reward	**Planned feature**. This is related to Status/Affirmation in Paragraph 7.4
	Social Role	**Additional feature.** This is related to Reputation in Paragraph 7.4.
	Remainders	**Additional feature**. It would remind users of their behaviours.
	Suggestions	**Additional feature**. It would fit suggestions for users to carry out healthy behaviours.

	Linking	**Planned feature**. It is a quite obvious feature that would make the tool visually attractive and appealing to the user (this is related to the focus group with users discussed in sub-paragraph 6.4.2.
System Credibility Support	Trustworthiness, Expertise, Credibility, Real World Feel, Authoring, Third Party, Endorsement, Verifiability	**Planned features.** These are typical features for a Web tool.
Social Support	Social Learning	**Planned feature.** It would provide means to observe others who are performing target behaviours and to see the outcomes of their behaviours. It would be based on Status/Affirmation and Reputation scores (see paragraph 7.4).
	Social Comparison	**Planned feature**. It would provide a means for comparing performances with others (same as above).
	Normative Influence	**New feature.** It would be based on means to leverage peer pressure and pressure from trustworthy persons (e.g. parents, relatives and friends, doctors, nurses, caregivers).
	Social Facilitation	**New feature.** It would provide means for people to feel that the others are performing the behaviour along with them.
	Cooperation	**New feature.** It would provide means for people to cooperate with the other.
	Competition	**Planned feature.** It would provide means for people to compete with other.
	Recognition	**New feature**. It would provide public recognition for users who perform target behaviour (It is related to achievements/changes in Status/affirmation and Reputation described in paragraph 7.4).

In particular the key features that would be considered to embed social interaction in DOREMI protocol are related to the following characteristics of the system:

- Dialogue support.
    - As already commented in paragraph 7.4 the possibility of the system to allow the users to recognise their social role it is an important enhancement for the adoption of the tool by the older population. This can be based on the definition of the reputational level of the user based on a combination of several social parameters as discussed in paragraph 7.4.
    - Remainders and Suggestions on how users are performing their behaviours and which could be remedial actions are also an important feature for the adoption of the system by the older population.

The above features would be integrated with social support functionality of the system as described in the table. In particular they would be integrated with the already planned social features such as: social learning feature; social comparison feature; competition feature.

However new social features would be considered in the DOREMI protocol as described in the above table. They are:

- Normative Influence feature. This would allow the users to engage in a healthy lifestyle through pressure of their peers and of their parents, relatives, friends, doctors, nurses and caregivers.
- Social Facilitation feature. Users would be more engaged in a healthy lifestyle because of the system to help them support peers that are performing less well.
- Recognition feature. This is related to the two features above and it aims at stimulating the social involvement of the person through public acknowledgment of the achievements of their healthy lifestyle management.

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10. APPENDIX

10.1 List of activities reported by Focus Groups (see 6.4.2)

Physical activities	**Traditional games and activities**	**Computer based activities**	**Other activities**
Gym	Quiz night	Computers	Travelling
Golf	Quiz games	Skype	Dining out
Billiards	General knowledge	Internet	Reflexology
Archery	Word games	Reading books on a tablet	Going to the

			market
Football	Crosswords	Photography	
Athletics	Scrabble	Candy Crush	
Sport	Code words	Splash	
Athletics	Poetry	Triviador	
Walking	Reading	Pointless (general knowledge game	
Swimming	Trivia games	Poo (avatar game)	
Boules	Whist	Solitaire (online)	
Petanque	Choir	Bridge (online)	
Yoga	TV	Poker (online)	
Rugby		Chess (online)	
Exercise			
Dancing			
Tai-Chi			
Golf			

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