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Smart, User-friendly, Interactive, Tactual, Cognition-Enhancer, Yielding Extended Sensosphere
Appropriating sensor technologies, machine learning, gamification and smart haptic interfaces

[Deliverable 7.1]

Recommendations for Gamified Solutions and Social Interaction

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Glossary	
Abbr./ Acronym	**Meaning**
AbES	Audio-based environment simulator
VIP	Visually Impaired People
Gamification	The application of game mechanisms to other areas of activity
Exergame	The activity of playing video games that involve physical activity
Accessibility	Design of products, devices, services, or environments for people who experience disabilities

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Executive Summary

In WP7 "Gamification and Social Interaction", we report on work that explore the use of gamified technology to improve the engagement, and general accessibility of technology. In order to understand recommendations for gamified solutions, we consider existing research on accessible gamified interventions, taking into consideration strategies, and recommendations elicited by previous literature.

Introduction and Rationale

Gamification research is a large field, and studies describe it broadly through two main concepts: "presence" and the state of "flow". Both describe a state where individuals feel immersed in the task at hand. Presence refers to the ability to provide the illusion that one is in a virtual environment [28], while flow can be defined as a state of concentration, deep enjoyment and total absorption in an activity [15]. Flow is the result of the balance between two different psychological states, anxiety and boredom, themselves produced by the gathering of two aspects of gaming: the challenge of a task versus the abilities of the player [6].

Gamification has been successfully used to improve excitement and commitment regarding technology mediated interventions for people with a range of accessibility issues. Individuals with, for instance, visual impairments have been found to consider gamified interventions more encouraging towards the long term use of learning enviroments [8], and have been found to positively impact task performance (e.g. enhanced spatial recognition [7]).

In the upcoming sections, we present an overview of accessible gamified interventions. We further provide a list of reccomendations for the design of gamified solutions for developing accessible technology.

Overview of Accessible Gamified Interventions

A growing body of research has focused on the incorporation of gamified strategies to encourage the use of technology-mediated interventions by individuals with a range of disabilities. The main approach of such interventions has been to make interventions more enjoyable, and motivational. For example, Kato et al. [16] have demonstrated that gamification can be an effective means of increasing compliance. Similarly, Achtman et al., found that gamification can help patients follow through with otherwise tedious therapy routines [1]. Gamified technology has been applied to teach sign language to deaf children [14], to support children with autism [11] and to provide cognitive training for children with syndromes [5].

According to Yuan et al [29], interactions with gamified software are comprised of three steps: First, users should be able to (1) receive stimuli, then they should (2) determine response to stimuli, and (3) provide input. The subsequent steps rely on each other. For example, if a user cannot receive stimuli, this will impair their ability to successfully determine what response to provide. A classical example is made with the game of Tetris: (1) Players see a falling block, and music can be heard; (2) The player decides to change the block's orientation and position and then drops the block; (3) The player presses the arrow keys to move and rotate the block and the space bar to drop it.

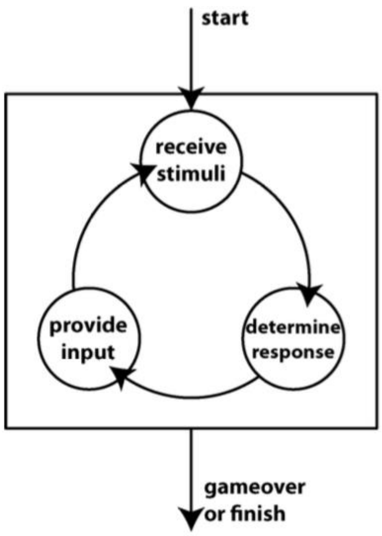

Fig 1. Game interaction model (as displayed in [29]). Gamified technology is interacted with in three steps: receive stimuli, determine response, and providing input

Individuals with impairements may be affected in each of the previously mentioned three steps: players with visual or hearing impairments may be unable to receive stimuli, individuals with cognitive impairments may be unable to determine an in-game response, and individuals with motor impairments may be unable to physically provide input.

To address such issues, on one side, a number of authors have focused on exploring different modalities towards making gamified elements, and games in general, more accessible. Morelli et al.

[18] developed a series of accessible versions of commercially available games (e.g., Nintendo Wii Sports Bowling and VI-Tennis). In their games, the authors replace visual cues with auditory and tactile feedback. VI-Tennis [18], for instance, was evaluated with children. The researchers measured the difference in energy expenditure, scores, and enjoyment from the original Wii Sports game. They found that people scored better and enjoyed the game more with the accessible version and produced health benefits due to physical activity. VI-Bowling, evaluated with adults, was found to be enjoyable and a sufficient challenge. Gutschmidt et al. use haptics and audio to make the game of Sudoku accessible for blind, to try out how to use haptics for conveying common accessibility issues for blind like overview and state feedback. Sepchat et al [25] presents their work with tactile video games for blind using a one-dimensional Braille display alone.

This focus has also been placed within specific areas of intervention (e.g. rehabilitation). A common finding is that game design elements improve the engaging qualities of these tasks. In the remainder of this section, we provide an overview of research which has employed gamification within technology-mediated interventions, across three specific areas: therapy and rehabilitation, spatial awareness, and learning environments.

Therapy and Rehabilitation

Recent years have seen much interest in the use of gamified technology to improve the engaging qualities of therapy programs.

One of the core challenges of this work is translating therapy requirements into effective, yet engaging game mechanics that have the potential of eliciting the same type of observable behavior as traditional therapy, while providing an enjoyable experience.

Rector et al. [20] developed Eyes-Free Yoga, an eyes-free yoga exergame that provides balance training for people with vision impairment and builds on audio cues to guide player movement. Eyes-Free Yoga provided instructions for yoga poses and custom feedback to help players improve their poses. To create a game that provides a similar experience to studio yoga and includes proper techniques, a yoga instructor was included throughout the game design iterations. Through a field study, users were found to enjoy the game, and find it helpful to help them understand the conveyed poses. Waddington et al. [27] developed *Eyelander*: a video game designed to engage children and young people with visual impairments, in compensatory training. The core game mechanic required players to visually search arrays of coloured shapes in order to find specified target stimuli, and to click on those targets. Correct clicks triggered both audio effects. The search tasks were framed by simple audio feedback, displaying progression in the game, as a means for introducing challenge, goals and driving longer-term engagement. A six-week field deploymen of *Eyelander* revealed a significant improvement in visual search skills, and compliance rate across 9 participants.

The use of games for the purposes of vision therapy presents a number of interesting opportunities. For example, there is some evidence that video games can improve participant motivation to engage with often-repetitive therapy tasks. In order to generate this type of motivation, games must present challenges to participants [20].

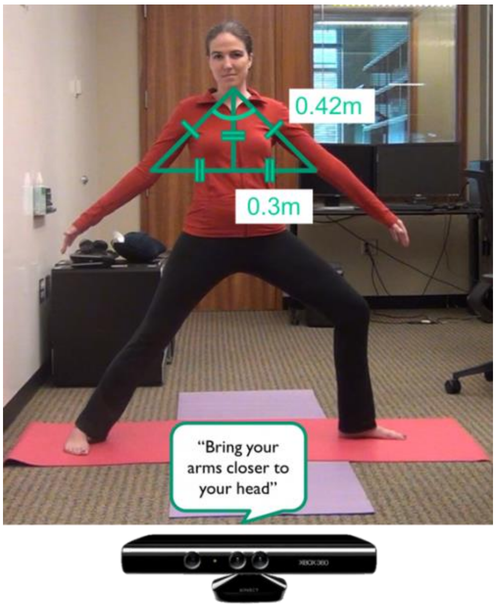

Fig 2. Therapy and rehabilitation interventions have increasingly used gamified technology, in an attempt to enhance compliance. Among such are *Eyes-Free Yoga* (left) [20], and *Eyelander* (right) [27]

Spatial Awareness

A range of research have explored novel, gamified approaches to train navigation and spatial cognition of individuals with visual impairments.

Connors et al [7] investigated the ability and efficacy of visually impaired adolescents to acquire spatial information from the exploration of a virtual environment, set in an action video game metaphor. Participants were assessed on their ability to transfer, and mentally manipulate, acquired spatial information on a set of navigation tasks carried out in a virtual environment. As an index of game play performance, "jewel points" were provided to participants as they actively manipulated their mental spatial representation throughout a building layout. Interestingly, individuals experienced enhanced navigation performance while using the game, as compared to an explicit route learning strategy. Performance was significantly correlated with real-world navigation task assessment, suggesting that the better an individual engages and succeeds in carrying out the exploratory goals of the game metaphor, the better the overall spatial knowledge acquired that is ultimately transferred for the purposes of real-world navigation tasks. Authors conclude that the immersive and highly interactive nature of the software greatly engages the blind user to actively explore the virtual environment.

Savidis et al. [24] discuss the development of a 2D pong-type game space that supports directional auditory and haptic feedback to enable blind users to perceive the position of moving targets, also offering a visual interface for sighted players. Different levels of difficulty are supported, affecting task performance.

In the Phase project [21], an experimental game which used haptic feedback towards enhancing mobility skills. A set of studies showed that games enhanced people's mobility skills when navigating the real-world space that was mapped by a virtual game.

Sánchez et. al [23], developed Audiopolos, an audio and haptic based videogame designed for developing orientation and mobility skills in people who are blind. Through a field study, Audiopolis was found to lead to markedly high performance levels in the users during the training tasks.

Fig 3. Gamified approaches have been used to train navigation and spatial cognition of individuals with visual impairments. Among examples are *Audiopolos* (left) [23], and *AbES* (right) [7]

Learning Environments

Interaction through gamified systems have been used as a means to teach important concepts and subject material (such as problem solving in science and mathematics) as well as interacting with complex spatial constructs that might otherwise be difficult to learn through more traditional didactic means.

Eriksson et al. [8] developed mini games designed for visually impaired children, with the goal of encouraging children to practice the recognition of simple visual objects. Results of user studies show that these are considered helpful by players with a wide range of visual abilities.

Mon and Meng Yap [17] developed a computer simulated learning environment to support visually impaired children in the learning of new shapes. The application used haptic technology, together with an audio gamified system. Based on the findings, 79% of the users agreed that the game was useful, and motivating, towards learning the shapes of new objects.

During the TiM project [2], funded by the European Commission, several tactile games were developed [3,10]. One was FindIt, an audio/tactile discovery and matching game intended for visually impaired children. Players had to associate sounds with pictures on the screen or tactile information on a tactile board. Among findings, authors highlight the importance of compensating the lack of visual information in order to ensure that the adapted game has enough attractive feedback for visually impaired individuals [4].

Design recommendations

Recent research suggests gamified systems as an effective means to engage and motivate individuals during technology mediated interventions. In this section, we elicit a range of design considerations for the development of these systems.

Challenges as an opportunity to empower and motivate

In order to present engaging and meaningful experiences, interventions must present appropriate levels of game challenge to individuals [26]. These challenges are the central means through which games generate motivation and engagement towards engaging with technology.

Most research on gamified interventions for individuals with impairments focus on ways of designing around the disability to provide a positive player experience (e.g., [18]). Another approach is to highlight individual abilities through exposure to challenging tasks (e.g., [27]). For instance, Waddington et al [27] developed a game-based therapy system aimed at supporting the engagement and adherence of young people within vision impairment therapy. The core game required players to search arrays of colored shapes in order to find specified target stimuli, and to click on those targets. Correct clicks triggered both audio effects, and haptics (vibration). The search tasks were framed by simple animations that introduced progression to the game, as a means for introducing challenge, goals and driving longer-term engagement. The player was presented with a goal for the play session (i.e. complete ten numbered levels) and medium term goals (i.e., a character climbing a ladder), which helped track progress. *Eyelander* helped therapists understand the individual visual capabilities of patients by giving players a platform on which they could demonstrate visual competence. In this context, the fact that therapists expressed surprise regarding the abilities of some players highlights the potential of empowering players with disabilities by allowing them to share abilities with others through play.

One of the core challenges dealt with in the design of accessible gamified systems, lay in judging the balance between presenting the player with necessary (e.g. therapeutic), and motivating challenges, while ensuring that accessibility guidelines are considered and players are not unnecessarily frustrated. Further complicating the game and task requirements can sometimes be contradictory. The activities necessary for successful tasks (e.g. those associated therapeutic recovery, or spatial navigation) are not always the most fun feature to be implemented into games. These types of challenge have the potential to frustrate participants and players, and could lead to disengagement with the design process, or with the resultant system. Designers of gamified systems should consider, and address the balance between both necessary and motivating tasks. For instance, playing the same game every day for a number of months is probably not what participants would choose to do. Nonetheless it may become necessary in some cases (e.g. therapeutically necessary). Generally, therapy may involve overstraining patients and pushing them to work at the limits of their abilities, whereas games try to balance challenge and ability to allow optimal experience [22].

Designers of games must consider and address both types of challenge simultaneously when defining in-game tasks. In addition, gamified systems should allow the participation of therapists, caregivers and players in the design of gamified interventions, in order to allow for input, and intuitive judgments over the design process – e.g. whether progress is being achieved [20].

Task-appropriate mechanics

A major research focus has been placed on assessing the outcomes of gamified elements within specific areas of intervention (e.g. rehabilitation). In this sense, it is essential that gamified interventions are tailored to specific needs associated to the specific area of intervention.

When training a skill via game play, it is crucial that the target skill must form the basis of the core game mechanic [9,13]. For example, if the therapy is designed to improve dynamic balance (e.g.,[9]), the principal way in which players interact with, achieve success in, and progress through, the game should be through measures of their ability to balance. In the case of *Eyelander*, for instance, the core mechanic involved the repetitive visual searching of an array of distractor stimuli in order to find a target, since this is the behaviour that is targeted by existing vision therapy.

In line with this requirement, Grammenos et al. [12] introduced a structured design method for developing gamified technology. Two main steps were identified towards the initial design of these systems (respectively points 1 and 2+3, as seen in Fig. 3). The first step (*Abstracting task-based game design*) pertains the identification, and breaking down of high-level tasks performed by individuals when taking part in a certain intervention – as well as the things they do, and need to know. This is followed by a *specialization, and appropriateness analysis for design alternatives*. In this step, the high level tasks resulting from the initial step are mapped to multiple physical alternative interactive designs, aligning with individuals' accessibility barriers (e.g. low vision, blind, deaf). In this context, accessibility barriers that can possibly emerge in each task when performed by a particular user group are identified and suitable alternative interaction methods and modalities are selected. These barriers are used to guide the design, and appropriateness of specific gamified elements.

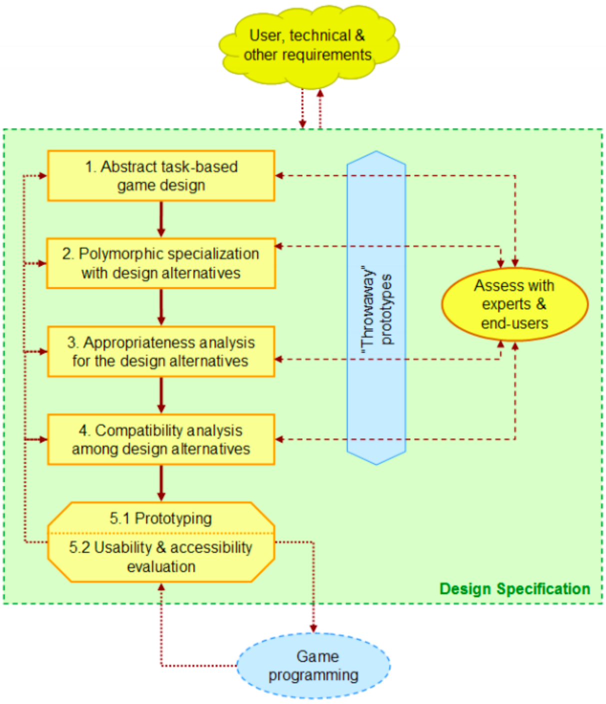

Fig 4. Unified design process for the development of gamified interventions [12]

End user adaptability, and fun

Two main approaches have been adopted when developing accessible gamified sotware: (1) An existing game is made accessible by replacing, or reducing, the reliance on a certain stimuli (in the case of deafblind, by replacing, for instance, visual stimuli's with haptic feedback); (2) Gamified interventions are specifically developed to accommodate a particular disability. In both cases, game mechanisms – and corresponding technology, are tailored to individual impairments, and capabilities.

Converting feedback from one modality into another modality often leads to loss of information. For example, the resolution and detail of stimuli received from a visual modality is much larger than what can be perceived through haptic modalities. Audio games often reduce the amount of feedback provided when compared with the original game so as not to overwhelm the player. Users must determine what response to provide based on a smaller amount of information. These tradeoffs may significantly alter the original gameplay, and end up creating a gamified system that is not fun to play. When making games accessible, it is important to understand how the game-play must change to avoid creating a gamified system that is not fun or challenging to play. To avoid any changes in the gameplay, it is important to preserve original input options as much as possible.

A number of stakeholders should be consulted in this process, beyond the individual with disability (e.g. therapists, caregivers), towards assessing potential risks, and contributions towards the end-system. For example, through the process of developing game-based rehabilitation technology for adult stroke patients, Flores et al., [9] found that it was important to allow the user therapist the ability to adapt complexity of both the visual content and the cognitive challenges presented by the game.

Conclusion

This document presents an overview of the current state of research and practice in gamification in accessibility. A number of accessible gamified systems were surveyed for different types of impairments, and the strategies used to make them accessible were discussed. In general, these systems have been successfully used to improve excitement, and commitment regarding technology mediated interventions for people with a range of accessibility issues. Guided by previous research, three design recommendations were derived, towards creating accessible gamified solutions:

1 – **Appropriate levels of game challenge to individuals**. Gamified systems should present challenge to participants towards driving engagement. Existing game design elements (e.g. goals, rewards, leaderboards) should be integrated into such systems, and tailored individually;

2 – **Keeping gamified systems fun:** Designers of gamified systems should consider, and address the balance between both challenging and motivating tasks, while ensuring players are not unnecessarily frustrated. Systems should be developed, and evaluated, in close cooperation with users, and stakeholders (e.g. family members), in order to allow for input, and intuitive judgments over the design process, and;

3 - **Tailor gamified elements to areas of intervention.** When training a skill via game play, it is crucial that the target skill must form the basis of the core game mechanic**.** For example, if a system is designed to improve dynamic balance, the principal way in which players interact with the game should be through measures of their ability to balance. The better an individual engages and succeeds in carrying out the goals of the game, the better, ultimately this skill may be transferred to real-world tasks.

While an ongoing focus has been placed on increasing the accessibility of gamified software (i.e. games for all), one must note a lack of literature regarding gamified solutions developed for people with deafblindness. Little is known about what type of games are being played or what level of barriers are faced. Very few games have been developed for players with deafblindness, likely due to the complexity and variable of impairments (from total deafblindness, to partial deafblindness which implies different combinations of hearing and sight impairments). While we believe that the insights put forward in this document serve to inspire, and guide the development of gamified software for the people with deafblindness, we believe the lack of research highlights the need to focus on this particular group. Within our work in the SUITCEYES project, we intend to push the research on gamified software forward – identifying the needs, and some solutions for the deafblind community.

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