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

Courtesy of LightHouse for the Blind and Visually Impaired, see http://lighthouse-sf.org

[Deliverable 7.3]

Documentation of Agreed Concepts

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Glossary	
Abbr./ Acronym	**Meaning**
HIPI	Haptic Intelligent Personalized Interface

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Executive Summary

In this deliverable, we draw insights from previous literature on gamification (D7.1) - as well as insights from the experiences of individuals with deafblindness with games (D7.2), to define a number of guidelines for creating games or gamified scenarios for individuals with deafblindness. We present a number of game designs, and explore the underlying requirements of each.

Introduction and Rationale

Games are an integral part of our well-being, social relationships and everyday fun and learning. However, most are inaccessible to individuals with deafblindness. Commercially available games rely strongly on visual or auditory stimuli in order to engage users into gameplay, leaving only a minority accessible for individuals with a dual-sensory impairment of vision and hearing.

In this deliverable we integrate results from literature (D7.1) with those we derived from user interviews with the target group (D7.2) to create a number of guidelines for creating explicit concepts for games and gamified scenarios which enhance social interaction and joyful experiences for deafblind individuals using the HIPI (Haptic Intelligent Personalized Interface).

The following sections will describe the process of creating those concepts. We start by summarizing the content of our previous work from D7.1 and D7.2. We then describe how the results from these documents informed the creation of a number of games designed specifically for individuals with deafblindness. Section “Social, Gamified Experiences” presents the concepts we created in detail, followed by an explanation on how we reached agreement which ideas are implemented at first. We conclude with an outlook on our future work.

Insights from "Recommendations for Gamified Solutions and Social Interaction" – D7.1

In this section, we report on the main highlights of the literature review conducted in deliverable D7.1, which explores guidelines for the development of gamified solutions for individuals with visual and/or auditory impairments.

Summarized Content of D7.1

Gamification is a large field of research, and studies describe it broadly through two main concepts: the concept of 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. As described in D7.1, the use of gamification has been found to engage individuals with visual impairment in rehabilitation [15, 19]; motivate the training of navigation and spatial cognition [6, 17, 18]; and shape learning environments into encouraging and appealing experiences [1, 4, 7, 8].

As highlighted in D7.1, the incorporation of gamification into daily tasks (such as rehabilitation or spatial orientation), offer the potential of improving motivation to engage with often-repetitive tasks. Tasks such as training navigational or balance skills may be perceived as a game, instead of a task. Assuming the right amount of challenge, those gamified scenarios can create a state of flow which enhances the user experience and the overall well-being of the user during such tasks.

Design Recommendations for Gamified Approaches

In D7.1, several design recommendations for the development of gamified approaches are derived from previous literature. First, in line with the varying degrees of deafblindness, the level of complexity of gamified solutions should be customizable. Second, there should be a balance between motivating and necessary tasks. Therapeutic or learning tasks can be monotonous and lengthy. By integrating enjoyable tasks and enriching feedback regularly, we can heighten the chances of having users stays motivated and engaged. Third, when using gamification to train a skill via gameplay, it is crucial that the target skill must form the basis of the core game mechanic. For example, if therapy is designed to improve dynamic balance (e.g.,[9]), the principle way players interact with, achieve success in, and progress through the game, should be through measures of their own ability to balance.

Insights from “Refined Recommendations for Gamified Solutions and Social Interaction” - D7.2

Deliverable D7.2 reports on the insights from interviews with deafblind individuals in which their understanding of playfulness, their needs as well as their preferences towards games were assessed. These insights lead to a list of design indications for developing gamified scenarios, and games, presented in D7.2.

The Definition of Play and Playfulness

In D7.2, the activity of playing is described as an observable behavior, which is defined by a variety of characteristics: play includes a certain degree of choice, is exploratory in nature, intrinsically motivating and offers freedom to handle objects, materials and ideas in an unconventional way [5, 12].

On the other hand, playfulness is seen as an attribute, enabling individuals to transform an environment or a particular situation into an enjoyable or entertaining experience [14]. Individuals featuring this trait are typically “funny, humorous, spontaneous, unpredictable, impulsive, active, energetic, adventurous, sociable, outgoing, cheerful, and happy, and are likely to manifest playful behavior by joking, teasing, fooling around, and acting silly’’ [1, p.955].

In childhood, play and playfulness are important means for practicing various abilities, such as cognitive, language, motor and social skills [3, 9, 11]. Moreover, just playing for the sake of play is considered to be equally important for development [10].

Understanding the Definition of Playfulness by individuals with Deafblindness

Individuals with deafblindness face large challenges, when it comes to playing games. Most commercially available games rely on visual or auditory cues, making it hard for deafblind individuals to engage in gameplay (e.g., keep track of a game’s state, determine appropriate in-game responses or interact with other players).

In order to develop entertaining and accessible gamified scenarios for the HIPI, it is crucial to understand the definition of playfulness by people with deafblindness, and their preferences and needs towards games. We, therefore, conducted interviews with concerned persons, in which we asked them to describe a memorable experience with a game, what they enjoyed about this game, as well as eventual challenges faced when playing it.

Semi-structured interviews were conducted with 28 individuals with deafblindness, each lasting 30 to 50 minutes (21 male, 7 female, mean age = 53). The interviews revolved around two main questions. First, participants were asked to describe a memorable game they played. We asked the participants to describe what they enjoyed about this game, and the challenges that arose when playing it (if any). Second, participants were asked to describe a game they used to play but are no longer able to play (if any). We asked them what they liked about this game, and the reasons that led them to abandon it.

The analysis grows out of thematic analysis. Interviews were transcribed, coded and organized into emerging themes, closely following the phases of thematic analysis suggested by Braun and Clarke (2006). Iterative rounds of discussion and refinement were performed between authors, looking for salient themes from interviews. We present the resulting themes as design indication for developing gamified scenarios for individuals with deafblindness.

Design Indications for Developing Gamified Scenarios

The analysis of the interviews led to a list of recommendations on designing accessible and enjoyable gamified scenarios for deafblind individuals:

- **Mediation of social interaction**: The support and enhancement of opportunities to connect with others should be a central aspect when designing gamified experiences or games for individuals with deafblindness. Due to the difficulties of a dual-sensory impairment, social interaction during playing is less frequent and distorted, which clearly reduces fun and sense of community. This highlights the importance of making the "inherently social aspect" of games accessible again and providing opportunities to reconnect with loved ones [13].
- **Customization of challenge**: Deafblindness is a condition which can manifest in a large variety of different abilities and limitations. To offer playful activities which are accessible to as many deafblind individuals as possible, the levels of challenge need to be customizable. Whereas some individuals are motivated by being challenged, others might feel overstrained.
- **Comprehensibility of rules**: A requirement, crucial for clear rules and in-game responses is to transform all stimuli relevant to gameplay and relying on visual or auditory cues into perceivable modalities for deafblind users, e.g. tactile stimuli. However, it is important to keep in mind that excluding too many stimuli might make the game less fun to play. Stimuli not relevant to gameplay might be removed completely to simplify the game mechanics and avoid overstraining. Additionally, deafblindness is often accompanied by mild to moderate cognitive impairments, which further supports the need for comprehensible game mechanics.
- **Access to game-related information:** For many deafblind individuals, games are "black boxes", which provide little (if any) cues besides visual and auditory ones. Therefore, continuous access to the current state of game (e.g. moves of other players) is needed. This keeps individuals entertained while waiting for their turn and can enhance social interaction and fun.
- **Promote physical activity:** In the interviews presented in deliverable D7.2, many participants mentioned some kind of sports game they used to enjoy during their childhood or young adulthood (e.g., soccer, basketball, volleyball, rowing, etc.). With deafblindness, individuals are highly disadvantaged when it comes to performing physical activity and sports. With a progressing deterioration of vision and hearing, playful activities featuring physical activity are performed less often and sports are abandoned. Some of the interviewed participants mentioned missing the aspect of engaging in physical exercises after abandoning sports. Therefore, we decided to create playful concepts promoting physical activity. Due to potential limitations in mobility and coordination of deafblind individuals, we focused on creating several concepts with different levels of physical activity (sedentary, moderate activity and dynamic).

Concepts for Social, Gamified Scenarios

Based on the requirements determined in the previous section, we derived a number of gamified scenarios for experience enrichment and enhancement of social interaction. Starting with a design brief of “gamified scenarios for social interaction, fun and learning”, a number of concepts were created. Each scenario was designed with the following requirements:

- First, a scenario either focused on *movement* or on *simply having fun*. As pointed out in deliverable 7.1, integrating game elements into therapeutic skill training can enhance motivation and fun. Individuals with deafblindness may experience a range of limitations on movement or learning and opportunities can be improved by regular skill training (e.g., navigation or spatial orientation). Deliverable 7.2 emphasized that “play just for the sake of playing” is important and that playfulness describes an individual character trait. Therefore, besides games for learning, we also created games that focus exclusively on entertainment and fun;
- Second, each game should be able to be played socially (i.e. with others). As noted in deliverable 7.2, individuals with deafblindness looked for opportunities to enhance their daily social interactions.

Based on this collection, we determined concepts which can be adapted to the needs and requirements of individuals with deafblindness (e.g., replacement of visual and auditory stimuli, mediation of social interaction, comprehensible rules and responses). As mentioned before, we focused on providing scalable concepts, i.e., varying levels of complexity and physical activity. Specifically, our concept “Pong” (see page 15) was adapted from the accessible version for blind or visually impaired individuals by [16], which has been described in deliverable D7.1. Eyes-free Yoga by [18], which has been also described in D7.1, inspired us to create the skill training “Tapping Game”.

The gamified skill training scenarios we developed are based on fundamental mobility and navigational skills, which represent common difficulties within the community of deafblind individuals: goal-oriented navigation (“Easter-Egg Hunt”, “Police Chase”), spatial orientation (“Get Back Home”) and coordination (“Rhythmic Exercise”).

We derived ten gamified scenarios for experience enrichment and enhancement of social interaction. In the following section, we present each scenario. A short description of the game mechanics is provided, the goal of the gamified concept and an explanation on the ranking of the cognitive and technical requirements.

Gamified Social Interaction Scenarios (Just for Fun)

1) Bowling

Goal: Hit as many pins as possible.

Description: Bowling pins need to be hit with a soft ball. The pins are displayed on a stand-alone plane, which is placed in front of the player on a table (or on the floor). When the ball hits the plane the number of hit pins is calculated, and the vest informs the player via tactile feedback.

Cognitive Requirements (Low): No fast reaction needed; easy game mechanics.

Technological Requirements (High): High computational complexity; external devices required (ball, plane).

2) Rock-Paper-Scissors

Goal: Score more points than your team-mate(s)

Description: Each player would wear a vest featuring three tactile buttons. One for each object: rock, paper and scissors. The vests connect to each other and all players press a button on their own vest. When time has run out, the button which was pressed last is used to compute the winner. The vests give tactile feedback about who won and who lost the round. The vest would store the number of times each person won, and translate it via haptic feedback (one long vibration would represent one victory, two to represent two victories, and so on)

Cognitive Requirements (Low): No fast reaction needed; easy game mechanics.

Technological Requirements (Low): Fast and easy computation; no external devices needed.

3) Pong

Goal: Keep the ball in the game, make your team-mate lose the ball

Description: Two-player game, in which a ball moves from one side of a rectangle field to the opposite. The ball is a real-time, constantly moving, vibration which can bounce off the borders of the game field. Each player controls a paddle, with the goal of preventing the ball from falling off his side of the game field. If placed correctly, the ball bounces off the paddle and directs to the other player's side of the game field. If the player chose the wrong location, the ball passes by the paddle and gets lost. The opponent scores one point. The vest transmits this information to the players via tactile feedback.

The two-dimensional game board is transmitted to the back of each player. On the top of the back is the opponent's side, at the bottom the players' side. Each player has a flexible touch screen on their wrist. The player should place their finger on this surface where they think the paddle should be placed. Haptic feedback would be used to indicate the movement of the paddle.

Cognitive Requirements (High): Fast reaction needed; game mechanics and game setup are rather complex.

Technological Requirements (High): High computational complexity; external devices required (paddle).

4) Humanoid Domino

Goal: Find your matching patterns.

Description: Every player gets two distinct vibration patterns. All players need to find their corresponding pattern by asking for the patterns of the other players: by placing the hand on a vibration actuator of another players' vest, the other pattern can be felt. If a matching pattern is found the connection is recognized by both vests. Both players get tactile feedback. As soon as all players find their corresponding patterns, the game is over.

Cognitive Requirements (Low): No fast reaction needed; easy game mechanics.

Technological Requirements (Low): Fast and easy computation; no external devices needed.

5) Bingo

Goal: Get one row of selected numbers first.

Description: Every player gets a board with a grid of random, tactile numbers. The vest randomly selects numbers out of a predefined range and every player checks if the number is present on his own board. If it is, it can be selected. If one row is selected, the player presses a "bingo"-button and wins the game.

Cognitive Requirements (Low): No fast reaction needed; easy game mechanics.

Technological Requirements (Medium): Fast and easy computation, but external device needed (board).

Gamified Scenarios for Movement and Training

1) Easter Egg Hunt

Goal: Collect tokens using guidance of the vest.

Description: There are tokens (Easter eggs) which need to be collected. While moving around the player gets indications of the vest in which direction a token is located. A collected token is recognized by the vest and a point is scored. As soon as all items are collected, the vest gives feedback. Obstacle avoidance is also integrated to ensure safe navigation.

Cognitive Requirements (Low): No fast reaction needed; easy game mechanics.

Technological Requirements (High): High computational complexity; external devices required (tokens).

2) Tapping Game

Goal: Translate vibrations into leg movements.

Description: Different vibration patterns represent different leg movements. According to the patterns transmitted by the vest the player needs to perform the presented movements. The more correct movements a player makes, the more points he acquires. The vest gives tactile feedback about errors and rewards after the completion of error-free sequences. It is possible to connect to other vests and "dance" together.

Cognitive Requirements (Medium): Fast reactions needed, but easy game mechanics.

Technological Requirements (Medium): Fast and easy computation, but external devices for movements recognition needed (mat, bracelet on ankles, camera …).

3) Get Back Home

Goal: Find your way back to the starting point.

Description: A target destination is selected either by the player himself, or automatically by the vest. A navigation path is computed, and the player is led to the target destination via tactile feedback. After reaching the destination, the goal is to find the exact same way back and to stop at the correct starting point. The more accurate the player navigates, the more points he scores. The vest rewards the player for successfully completing sections of the path and in the end for the whole navigation process. Deviations from the original path are transmitted as well.

Cognitive Requirements (High): No fast reactions needed; easy game mechanics. However, the cognitive load of the game is high. A spatial map of the surroundings and navigational skills are required.

Technological Requirements (High): No external devices needed, however with a high degree of computational complexity (navigation, guidance, deviation from optimal path, …).

4) Police Chase

Goal: Follow someone to a certain distance and catch him/her when a signal is given.

Description: The player needs to follow another player to a certain distance as accurately as possible. The more confidently, faster and accurately the player follows the other, the better. The player is navigated by vibrations of the vest in the direction of the leading person. When a specific signal is provided, the player needs to catch the “thief” as fast as possible by reaching out his/her hand.

Cognitive Requirements (Medium): Fast reaction needed, but easy game mechanics.

Technological Requirements (Low): Fast and easy computation, no external devices needed.

5) Rhythmic Exercises

Goal: Make body gestures and movements following a rhythmic sequence.

Description: The player needs to perform a sequence of body movements according to a rhythmical sequence transmitted by vibration patterns. Every time the person receives a certain vibration stimulus the player needs to immediately clap hands, when another stimulus is transmitted the player needs to stomp with the respective foot. Each rhythm could be controlled by another person via Bluetooth or sent automatically by a music sheet editor/reader. If mistakes are made, the vest provides tactile feedback. The less errors made, the more points the player scores. It’s possible to compete or to play alone or in a team.

Cognitive Requirements (Medium): Fast reaction needed, but easy game mechanics.

Technological Requirements (Medium): Fast and easy computation, but external devices needed (bracelet on ankles/wrists).

Table 1: Overview of features of the derived gamified concepts.

Gamified scenario	Learning task	Scalable complexity	Level of physical activity	Cognitive requirements	Technological requirements	Development Process
Bowling	X	✓	Moderate activity	Low	High	Adapted
Rock-Paper-Scissors	X	X	Sedentary	Low	Low	Adapted
Pong	X	✓	Sedentary	High	High	Adapted
Humanoid Domino	X	✓	Moderate activity	Low	Low	Adapted
Bingo	X	✓	Sedentary	Low	Medium	Adapted
Easter Egg Hunt	✓	✓	Dynamic	Low	High	New
Tapping Game	✓	✓	Moderate activity	Medium	Medium	New
Get Back Home	✓	✓	Dynamic	High	High	New
Police Chase	✓	✓	Dynamic	Medium	Low	New
Rhythmic Exercises	✓	✓	Dynamic	Medium	Medium	New

Agreed Concepts for Social, Gamified Experiences

In this deliverable, we defined a number of requirements for the development of gamified experiences for individuals with deafblindness, and a number of specific gamified scenarios.

Generally speaking, all experiences listed in the section above "Social, Gamified Experiences" meet the predefined criteria from the section "Development Process of Social, Gamified Experiences". However, we decided to focus mainly on three criteria:

- Cognitive requirements
- Level of physical activity
- Technical requirements

Due to several reasons, we considered these three criteria to be the most relevant for the decision process. First and foremost, we want to meet the requirements of as many deafblind individuals as possible already from the beginning. In order to achieve this, we need to carefully consider the first two criteria: "Cognitive requirements" and "Level of physical activity". Considering both criteria, we can assess the different concepts with respect to their scalability for different levels of cognitive and physical abilities. The more flexible, and easy the basic version of the concept is, the better. Furthermore, we collected different approaches to increase the challenges (more physical activity or higher cognitive load). The third criterion "Technical requirements" assesses the concepts from an economic and practical point of view. The gamified, social approaches can be evaluated in user studies, in which improvements can be deduced and integrated. Additionally, the easier and more convenient a gamified assistive system is, the higher chance it has to be accepted by the target group. Acceptance, practicability and scalability are especially important for the target group of individuals with deafblindness. The abilities and disabilities of this target group are very diverse, which makes customization and early user evaluation the most important aspects for the introduction of gamified, social experiences.

Considering the preceding criteria, we agreed on two gamified, social experiences to start with:

1) **"Rock-Paper-Scissors"**: The game mechanics of this simple game are very easy, and a single game unit is very short. Further, team and single-player modes are available, likewise. Only little information needs to be transmitted to the players, while providing information about the other players' moves and results is easy as well. The computational complexity of the game is simple and therefore, the gamified, social experience can be provided in a relatively short time. This will empower us to quickly start user evaluations which will offer deeper insights into deafblind individuals' preferences on gamification and social interaction. These insights, in turn, can be integrated into the development process of more complex gamified, social experiences.

2) **"Police Chase":** The game mechanics of this gamified, social experience are easy, and the concept trains navigation and spatial orientation. Furthermore, the gamified concept teaches the users how to properly deal with the vest and playfully enhances the trust in the system. Creating trust

towards the system is a crucial aspect for implementing a successful, accepted assistive system, which is important for our project. Additionally, the computational complexity is relatively low and therefore, this concept can also be developed in a relatively short time.

Outlook

In this deliverable, we described the process of creating explicit concepts for games or gamified scenarios. All presented ideas were specifically designed to meet the needs and preferences of individuals with deafblindness. In the next step, two prototypes will be implemented and tested. At first, functionality tests will be conducted with students. In the next iteration, the prototypes will be evaluated by the deafblind individuals themselves. According to the results examined in the user study the prototypes will be optimized and re-evaluated until we have reached our goal to create enjoyable and playful games or gamified scenarios for individuals with deafblindness

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