Design of a Serious Game for Enhancing Money Use in Teens with Autism Spectrum Disorder

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Abstract. People with Autism Spectrum Disorder (ASD) show often substantial difficulties to understand the concept of money and how to manage it. The majority of them are not independent, even for the most basic financial activities. In this paper, we illustrated the design of a serious game (SG), *€UReka*, for teens with ASD to train skills useful to recognize and discriminate Euro coins and banknotes and to use them in real-life situations. We followed SGs frameworks for people with ASD and we adopted a participatory design, involving a multidisciplinary team. We included a short version of our game design document to explain how serious contents, game elements, and needs of the players with ASD were balanced in our SG. *€UReka* consists of two 3D mini-games set in real-life environments, with a simple storyline and user-friendly graphics. The player can individualize their gaming experience, customizing some game options based on their preferences and needs. We developed a first game prototype that will be evaluated through a usability test. In future works, a specific study will be planned to assess possible benefits from training with *€UReka*.

Keywords: ASD · Neurodevelopmental disorder · Serious game · Game design · Daily living skills

1 Introduction

Autism Spectrum Disorder (ASD) is defined as a complex neurodevelopmental disorder characterized by deficits in social communication and social interaction,

and by limited patterns of interests, activities, and behaviors [1]. It is often linked to intellectual disability, psychiatric impairments, and other kinds of comorbidities [17]. Several studies [6,10,12] reported that only a small percentage of people with ASD become independent in adult age. Hence, most adults with ASD require different levels of support, mainly provided by families that consequently are often under a great deal of stress [9,15]. On the other hand, the lack of self-sufficiency and employability among adults with ASD has an economic impact on society [2].

Money management is an important daily living skill, promoting and improving an independent life for people with disabilities within the different contexts of life [13,20,21]. In a qualitative study [5], 27 interviewed youth with ASD (16–25 years old) expressed concern regarding their lack of familiarity with money use and they reported problems even in basic skills, such as counting money or paying. While money usage may appear easy to learn and practice, it is actually quite complex and composite for people with ASD because money is an abstract concept and its use involves different abilities and knowledge simultaneously [3,8]. This can be briefly illustrated by considering a classic example of money usage: payments. In this activity, besides discriminating and recognizing money, mathematical skills (e.g., being acquainted with concept of quantity, counting, and doing arithmetic calculations) are necessary. Moreover, these skills have to be generalized and then applied to money usage in different life contexts. In addition, payments also require skills not related to money usage at all, such as attention, communication, and social skills [13].

Studies over the past two decades have provided good evidence to support using serious games (SGs) for teaching specific skills to children and youth with ASD [7,19]. Similar to other technological approaches, SGs respond to different needs of people with ASD: providing structure and predictable environments, giving priority to the visual channel, decomposing multiple steps into single levels, offering the possibility to repeat actions, providing feedback in different forms and regulating sensor inputs [4,11,18,22]. However, unlike other approaches, SGs display the structure of a traditional digital game, including game elements that can support the learning process and can be more attractive for children and youth with ASD [22]: in fact, as reported by Mazurek et al. [16], they spend more than two hours per day playing videogames, and they generally play more than people with other disabilities.

In this paper, we described the design of a 3D serious game €ureka, for teens with ASD aimed at understanding and handling money, specifically Euros. We also included a shorter version of our game design document to describe and illustrate game flow and structure.

2   Methods

Our SG design required a multidisciplinary expert team to determine the needs of our target audience, to identify the game elements that could be attractive for them, as well as to guarantee a balance between game and serious content. Specifically, we adopted a participatory design [14], involving a child neuropsychiatrist, a

psychologist, therapists, young adults with ASD, and biomedical engineers who are experts of technologies for people with ASD. Periodic team meetings were scheduled during the design and development phases to review each step, solve problems, and make decisions for each stage in an iterative process.

Several frameworks currently exist for SGs design for people with ASD, including both general frameworks providing universal recommendations [18, 22] and more specific ones providing effective indications to design SGs for particular application contexts [4, 11, 20]. We mainly followed the design guidelines proposed by Tsikinas et al. [20], focused on SGs aimed at improving independent living skills in people ASD. This approach stresses the importance to provide an individualized gaming experience in order both to enhance immersion of players with ASD and consider their heterogeneous needs. Individualization should include customization of certain game elements, especially sensor inputs, features of game avatars, and game difficulty. Another crucial game element that should be considered is the challenge factor: the game has to be stimulating, introducing progressively new tasks and goals based on the player's capabilities and their previous performance. Moreover, the authors suggested that SGs should be set in real-life contexts and reproduce real-life situations to facilitate the generalization process of trained skills and to respond to the difficulties of people with ASD in comprehending fictional narratives. In addition, SGs should provide the possibility to repeat game actions and levels to foster predictability and to facilitate the mastering of trained skills. A feedback system involving both visual and audio clues should be planned and provided to inform the player on the validity of their actions. Visually, simple and clear graphics should be used to avoid distracting players.

Furthermore, our research team added other key components to our SG design to motivate players and to provide a positive gaming experience. SGs should offer instructions and tutorials to guide players with ASD and to facilitate the gameplay [4]. In order to improve player engagement, a storyline, fun game elements, and a reward system should all be included while considering the interests of the target audience [18]. Based on these considerations, we elaborated a game design document to detail our designing process and to facilitate SG development.

2.1   Game Design Document

Description. Our SG, *€UReka*, consists of two different mini-games: *Shooting a basketball* and *Shopping in a coffee shop*. They are 3D games providing training for Italian teens with ASD to help them discriminate, understand, and handle money (€). When launching the application, the player has to create their avatar, choosing a character and providing a nickname. Subsequently, in the *€UReka*'s title screen, the player can select one of the two proposed mini-games and set up specific options (music and audio volumes, character customization, and game input controls). After choosing the mini-game, the player can select a level. More advanced levels are initially locked, so that the player can only select a new level if they have completed the previous one; otherwise, they will have to repeat the

level until they succeed. Each mini-game starts by introducing a main mission through a supporting character. A menu can be accessed to exit, save, return to the title screen, and edit settings. Upon completion of a level, the player receives an award depending on their game score.

Shooting a basketball: this mini-game focuses on recognizing and discriminating Euro coins and banknotes. The player has to associate the required money to the right image, number, and textual name before shooting a basketball in the basket featuring the correct option. The player has to shoot three times for each level (see Fig. 1): (1) first, they have to shoot the ball in the basket matching the image of the required money; (2) then they have to shoot the ball in the basket matching the number of the required money; (3) finally, they have to shoot the ball in the basket matching the textual name of the required money. Therefore, the game trains image to image, image to number, and image to text associations.

Shopping in a coffee shop: this mini-game aims to support money handling in a real-life setting. The player has to help a supporting character to buy products in the gym's coffee shop. The supporting character indicates the products to buy and gives the player a wallet with specific money at the beginning of a level. Then the player has to find the several products in the coffee shop, go to the cashier, select the right money from the wallet based on the amount due, and finally pay.

Goals. Our *€UReka*'s main purpose is to improve money-related skills. In particular, it aims to train and improve: coins and banknotes recognition; discrimination between coins and banknotes; association of image, number, and text to the corresponding money; money-related maths skills; money handling; understanding of payment dynamics; change management; understanding of the concept of the price.

Target Audience. Following Tsikinas et al. [20], we identified teens with ASD (aged 13–19 years) needing to learn and train their management skills as our main target audience.

Storyline. As suggested by Tang et al. [18], we provided a simple storyline with straightforward dialogues. In *Shooting a basketball*, the story revolves around a challenge: "Whoever shoots the ball in the right basket will earn an award!" The supporting character is a basketball coach providing information on the required money that the player has to identify each time. On the other hand, *Shopping in a coffee shop* focuses on helping the basketball coach to buy products in a coffee shop. Overall, the characters are: the player character (a boy or a girl) that can be selected at the game start; the basketball coach, a supporting character, who illustrates the game and its missions and helps the player by providing instructions when necessary (NPCs); coffee shop staff interacting with the player when required based on the game missions (NPCs); people spending their time in the coffee shop.

(a)

(b)

(c)

Fig. 1. Screenshots of the *Shooting a basketball* mini-game. The figure shows screenshots of the *Shooting a basketball* prototype. For each game level, the player has to shoot a basketball in the basket matching the required money. Image to image (a), image to number (b), and image to text (c) associations are required.

Game Environment. Different pictures and images were collected from the web and used as 3D guidelines to design the game setting. The *Shooting a basketball* mini-game is set in a basketball court (see Fig. 1), whereas *Shopping in a coffee shop* is set in a gym's coffee shop (see Fig. 2).

Fig. 2. Screenshot of the coffee shop environment. The figure depicts the game environment developed for the *Shopping in a coffee shop* prototype, which is set in the coffee shop of a gym and reproduces a real-life setting.

Player and Inputs. Actions that the player can perform are: moving back and forth; moving left and right; jumping; shooting the ball; selecting products in the coffee shop; selecting money from their wallet; selecting menu options. Before starting to play, the player can customize their input device, choosing between a joystick controller or a keyboard with a mouse.

Game Levels. The first level of each mini-game is designed as a special session with instructions that are useful to explain the game and its dynamics, as recommended by Carlier et al. [4]. The game difficulty increases progressively with each level. Specifics for each mini-game are as follows:

Shooting a basketball comprises 15 levels, one for each type of coin and banknote, starting from €0.01 and progressively reaching €500. For each game level, the player has to identify and choose a basket among two options, the correct choice being the one with an image of the required money. In the first few levels, the possible coins to choose from have clearly distinct colors and designs (e.g., €0.10 vs. €0.05); after the €0.50 level, the choice is between similar coins (e.g., €1 vs. €2) and between banknotes and coins sharing a few numbers (e.g., €10 vs. €1, €200 vs. €20).

Shopping in a coffee shop consists of 10 levels with increasing difficulty. More specifically, the game difficulty encompasses different elements: finding products in the coffee shop, the number of products to buy, money available in the wallet, and math calculations. For instance, in the tutorial level, the basketball coach asks the player to buy only one water bottle and the wallet contains only two coins (€0.50 and €1). In subsequent levels, with an added variety of products to buy and money to choose from, simple math calculations are required to understand the amount due and to calculate the change.

User Interface. As recommended by different frameworks [4,11,18], the user interface has a simple design that shows written messages for each game mission, including instructions, dialogues, and feedback. The written messages appear in a separate panel on top of the screen for game missions/instructions, at the bottom for dialogues, and in the middle for the feedback. The game messages and instructions are in Italian and are written in a simple and clear language.

Reward and Feedback System. For both mini-games, the game score is calculated based on the accuracy percentage of game activities performed. At the end of each level, the player can receive a reward depending on the game score they achieved, specifically three stars ($80 <$ game score ≤ 100), two stars ($60 <$ game score ≤ 80) or one star ($40 <$ game score ≤ 60). At the end of each mini-game, if all levels have been unlocked with the maximum score, the player will receive a special bonus: the title of best player. Additionally, during the game, the player will receive audio and textual feedback, both positive and negative, when they complete each task in order to reinforce their correct game actions or help them understand their possible mistakes.

Sound and Music. The goal of music within a game is to set the mood of the world, as well as to provide a feedback to the player. Our game features a basic music loop that is not too fast and can be heard in all game. Two different sounds are included for negative and positive feedback respectively. Sounds and music can be adjusted by the player in the settings; the audio can be turned off completely if it creates problems to the player.

Technical Specifications. Unity (version: Unity 2019.4.4 Personal (64) bit) was chosen as a game engine and the game should be executed as a Windows PC application.

3 Discussion

The current study presented an Italian SG, *€UReka*, that was designed to support teens with ASD in developing and training essential skills, specifically, understanding money and its management. The game was designed as a set

of two mini-games: *Shooting a basketball* aimed to train money recognition and discrimination, while *Shopping in a coffee shop* aimed to improve money management in real-life settings. Both mini-games were engineered as 3D games with multiple game levels at increasing difficulty. We designed a clear user interface, an intuitive storyline, a system of feedback and rewards, and the possibility to customize certain game elements, such as the player character, adjusting the audio settings and choosing the game levels.

In accordance with a previous study [3], the *Shooting a basketball* mini-game provides game dynamics conceptually based on the technique of association; namely, the player has to associate a coin or a banknote to the right image, number, and text. However, in contrast with this previous study, the association here is not carried out through a drag and drop mechanism, but it was implemented through a specific dynamic – shooting a basketball – in order to motivate and engage the player towards the goals. With *Shopping in a coffee shop*, we designed a life simulation game where the player has to follow real-life steps of the shopping experience. From a design point of view, this is in line with SGs proposed by other similar studies [3,8] and SGs developed to improve daily living skills [20]. In fact, reproducing a real-life experience can increase the immersion level of players with ASD while also facilitating the transfer of trained skills from the virtual world to real life [18,22].

A first SG prototype was developed following the design document. We scheduled a usability test with a target group to evaluate possible changes, supplementing and restyling the prototype. Currently, *€UReka* was tested on a PC running Microsoft Windows 10 (provided with 16 GB RAM and Intel Core i5 7th Generation) by young adults with ASD who are members of our design team. They described the game as pleasant, user-friendly, and motivating. However, based on the results of a future usability test, we plan to introduce common difficulty progression modes – easy, medium, hard – in order to individualize the game experience and to respond to all the needs of people with ASD. In future works, we will plan and organize a clinical trial to evaluate the efficacy and effectiveness of the SG-based training.

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