Keep Attention: A Personalized Serious Game for Attention Training

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ABSTRACT
Attention abilities may be altered because of different factors since childhood or during the aging process and may influence the daily lives of peoples. Attention troubles may be caused by different diseases such as Attention Deficit Hyperactivity Disorder (ADHD) which is responsible of many learning difficulties. The early diagnosis and surveillance of children's cognitive abilities can help in preventing the development of such diseases. Serious games may play an important role in helping tutors to assess the children's cognitive abilities and to get quantitative data about their progression. It can also be used as a personalized training tool that takes into account not only the individuals' abilities and training needs but also their motivation. In fact, training requires repetitive tasks which may decrease the individuals' engagement and motivation. In this paper, we present Keep Attention, a serious game designed to assess visual attention and to personalize the training experience. We highlight, in particular, the design framework we considered to deal with personalization issues.

Author Keywords
Serious games; attention training; design framework

ACM Classification Keywords
Applied computing → Computer games

INTRODUCTION
The success of video games and their implication in our culture nowadays is a consequence of the evolution of technologies and the diversity of internet facilities. Video games have nowadays the potential to be more than just entertaining. They are in particular used for other fields such as learning and cognitive rehabilitation. The potential of virtual reality systems and serious games has been explained by the brain plasticity resulted from environmental stimuli. The latter is considered among the basic principles of therapeutic strategies for many cerebral disorders [6] [13] [14].

Attention ability, or the mental focus on the most relevant information [2], is among the cognitive abilities that may influence the daily activities of people and their learning. Attention can be altered because of different psychological factors and deficits such as attention deficit hyperactivity disorder, which is the main cause of school difficulties [9]. In this paper, we present Keep Attention, a serious game for attention training. The objective of this game is to help tutors to evaluate the children's attention skills and provide them with personalized training experience. We consider the challenge of designing games that maintain the children motivation although repetitive nature of tasks in training. We propose a game design framework that takes into account the variety in game elements to maintain players' motivation as well the personalization of training to players' abilities.

The rest of this paper is organized as follows: Section 2 discusses the design and personalization of serious games for attention training. In section 3, we introduce the game design framework used to design serious games for attention training. We explain after that the personalization process in Section 4. Then, we present Keep Attention game we designed following the previous framework. Finally, we conclude this paper by presenting the primary pilot study results and our perspectives for future works.

RELATED WORKS
Different works studied the design and the personalization of serious games for attention training. The game feedbacks and the difficulty of the game were especially considered as the main strategies used to individualize the game experience. Attention games are often designed following a goal-oriented design method. They focus on a set of repetitive exercises to train the player and attend a particular learning goal. The player can be responsible to choose the level of difficulty according to her performances. For example, ATHYNOS is a Kinect based augmented reality game designed to children with attention deficits [1]. The game is composed of two mini-games, each one with three difficulty levels: Basic, Medium and Advanced that are selected by the child at the beginning of

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each game session. Fontana et al. [4] suggested Train Brain, a serious game for selective attention training. It is based on memorizing images in a one or different contexts using colored circle. The player also has to select manually the difficulty level. In this first approach, the design focuses on a gamification technique of a set of exercises that meet training objectives. It consists in including some game elements to the exercises to motivate individuals such as: avatar interaction and feedbacks. The primary objective of these works is to ensure that the training meets experts' expectations. In addition, the personalization does not consider the difficulty balancing and the user has to control the training without specific guidance about her progression and training needs.

The rationale behind of other works is to reuse existing casual games and try to adapt them to meet training objectives. The purpose is to ensure that the game is not composed only of a set of exercises but also offers to users a game experience as given with classical casual games. The finality is to enhance users' motivation and their acceptance of using the game as a training tool. For instance, Rijo et al. [15] developed a game for children with attention deficit and ADHD. The game is designed by matching learning objectives with some game elements. In particular, the player is asked to find and collect hidden treasures like letters, words, faces and objects to meet training objectives. They also added adaptive feedbacks to encourage children in listening and following verbal directions. In Veronica Montani et al. [12] an adapted game called LABYRINTH was proposed to train attention and executive functions for patients with traumatic brain injury (TBI). The difficulty of the game is dynamically adjusted based on players' performances. It depends on attention skills of an individual by calibrating the time on tasks, number of targets and speed in the game. The game gives also feedbacks on player's performance but without explanation of the attention evaluation process and the proposed difficulty.

Our objective in our work is to design a serious game that considers variability in game elements to maintain the individuals' motivation that may be decreased following repetitive tasks. The design of such games should also take into consideration the personalization of the training to players' abilities while offering a transparency of decisions and guidance proposed to players.

DESIGN FRAMEWORK

As training requires repetitive tasks, having a large number of games is quite important to avoid boredom in long term. One possible solution for tutors is to reuse some casual games in training. However, these games are often not personalized and do not provide tutors with quantitative data about the trainee's performance and progression on one hand. On the other hand, the development of various games may increase development costs.

In our previous work [5], we proposed an abstract game model that considers three levels: (i) task level (ii) scenario level and (iii) story level. This model directs players to accomplish goals around targeted skills [3]. The goals depended on learning objectives which highly limits the variability of game elements and scenarios.

To deal with this issue, we propose a task-oriented design approach that considers learning tasks as the building blocks of the serious game. Game elements, such as scenario, feedbacks, storylines and rewards, are independents from the learning objectives. They are used to create the gameplay using these building blocks. Only the task that is related to learning objectives without a specific "matching" with game elements. This may offer to the designer the possibility of more creativity when designing the game and to personalize it. At the same time, this not means that the serious objectives will not be met. The creativity in the game design is limited to the required tasks, or the building blocks, that are fundamental in the training. This may also help in the explanation of personalization model decisions by highlighting only the learning objectives without putting the light on the game elements.

The task-oriented approach allows variability in game goals that are not necessary planned for learning. We believe that balancing dynamically the goals between learning and fun according to the player's performances and situations may increase their engagement and acceptance of using games in daily training. In particular, players may be discouraged, tiered or loss attention during the training. These particular situations are more observables in players with health issues such as attention troubles [9] and stroke [6] and influence their performance. It is important to consider these conditions to maximize the training outcomes while maintaining the players' motivation. Following this design approach, the personalization of the game may play an important role to dynamically set the goals according to the player's situation. For example, when the player's loss attention and its performance decrease, the game may offer "a rest time", by limiting learning tasks and focusing only on game goals. This requires a continuous assessment of the player's situations to better personalize the difficulty and goals.

Following this design framework, we consider therefore two levels to build a serious game: the task level and the game level.

The task level

The task level determines the learning tasks that a player should perform to achieve learning goals. The task is represented though basic sequence of mechanics such as select a target, drag and drop objects, etc. It can be therefore represented by a pointing task defined by its difficulty that can be dynamically adapted following the player's abilities and progression in the game. In fact, we assume that the difficulty in a serious game is related only to learning

objectives. The task is related to the serious side of the game and can be for instance, in attention training, to reach a target within a timeout, avoiding obstacles, fire a target, etc.

The game level

The task is independent from a particular game element, such as the story, rewards or a particular aesthetics that are usually used to motivate the player. Hence, the learning objectives are implicitly defined according to the kind of tasks, their number, difficulty and order. When the task is for example to find and reach a target quickly, the target may be for instance a treasure to find or to feed a particular animal in the game level. This complete separation between tasks and game goals allows creating various scenarios in the same game, which may reduce development costs. It also makes it possible to dynamically setting game goals with a variety of scenarios in order to maintain the player's motivation.

KEEP ATTENTION GAME

We developed a serious game prototype for attention training that follows the design framework described above.

The task level

We focused in this game on selective attention that is the main responsible of school difficulties [9]. The task consists in selecting appropriate targets within different visual contexts [10]. The training intensity may be determined according to the number of targets and contexts as well as the number of obstacles. It also may be influenced by the time given to each task or the total time of the session. We considered that attention activity may be represented by a pointing task to reach a visual target in different contexts and with a particular accuracy by avoiding obstacles.

The game level

We defined different scenarios through game levels (in various worlds) that are dynamically generated at the start of the game session. Each game level imports its own targets' aesthetics and logics in the scenario. Figure 1 shows three examples of game levels:

- Zoo level: The objective is to rescue animals while avoiding insects and monsters.
- Card level: The player is asked to memorize card positions and find similarities according to their details and colors.
- Space level: The player has to fire all strange creatures that may attack the earth while avoiding space stations.

At the generation step, each game level may uses different game elements. For example, in a zoo level scenario, the targets may be bees and the obstacles are flies. In a second scenario, the targets may be cats and the obstacles are monsters. In addition, the characters are used in the game to create a variety of storylines and guidance to progress in the game.

PERSONALIZATION

The general personalization process is shown in Figure 2. At the beginning of each game session, the player can evaluate her attention by obtaining a daily score of her attention. This score is used to build the player's profile and consequently personalize the game to the player's current abilities and training needs. In particular, the number of successful targets found, including the presence of obstacles, the mean time on task as well as the total time to complete an exercise were collected to compute an attention score.

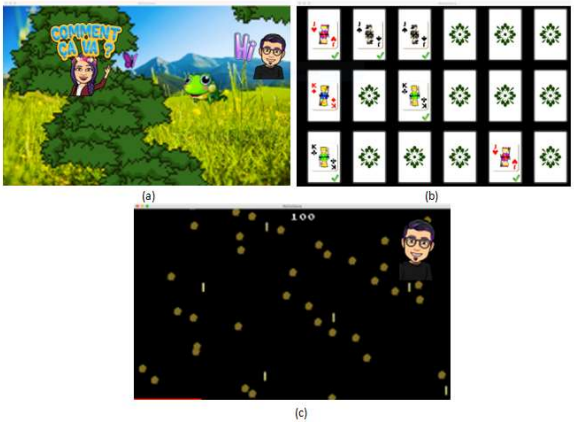

Figure 1. Keep Attention game levels: (a) Zoo level (b) Card level and (c) Space level.

In our previous work [7] we developed a set of assessment exercises of the attention following the Test of Everyday Attention for Children (TEA-Ch), a short WISC-I11 attention test adapted to children [11]. We dealt with the issue of the transparency of the user model and its influence on user's learning. These assessment exercises were included in Keep attention game. The players are asked to select targets (images) in different contexts, while adding obstacles (distractors), and a timeout.

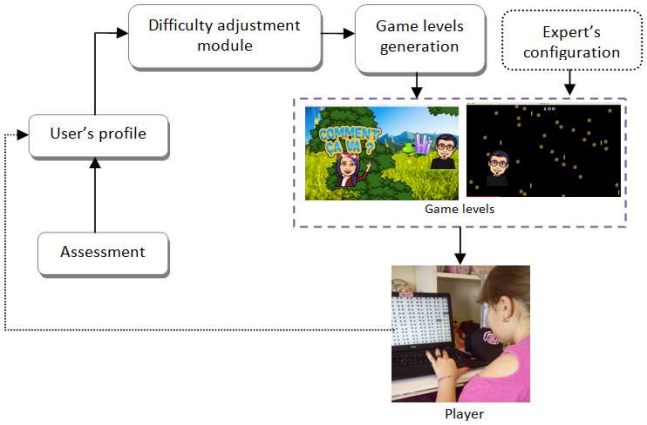

Figure 2. Personalization process of Keep Attention serious game.

Once the profile is updated, the difficulty adjustment module makes decision about the difficulty of suggested

tasks of each game level using a rule based system. Rules depend on general attention tasks' parameters such as: the number of targets, the presence of obstacles and the timeout. The decisions on difficulty are used then by the game level generator to set up the different game levels and goals, selected for training with adapted difficulty.

Finally, the tutors and experts may update the game as well as the difficulty parameters at their request. They also can configure the attention evaluation process by adding their models used to compute the attention score. This may help also researchers to build models from empirical data and make decisions on learning to enhance the individuals' attention.

PILOT EXPERIMENT

Eleven children aged between 8 and 11 participated to a primary pilot study to evaluate their experience when playing Keep Attention game. Participants performed the attention assessment exercises then played the game. At the end of the session, they answered the Game Experience Questionnaire - Core [8] using a scale of five choices <0: not at all; 1: slightly; 2: moderately; 3: fairly; 4: extremely>. Subjects were also asked at the beginning of the experience about their general information and their perception of attention level in daily activities.

We also recorded the subjects' performances from the assessment exercises, such as the ratio of reached targets in each exercise and the mean time on tasks, to determine their attention level score. We analyzed questionnaire core data components, especially the competence, the challenge, the positive and the negative effect of the game.

The results of this pilot experiment show that the participants found the game personalized to their abilities. They realized that the game objectives were clear and the scenario follows their performances. They reported that the difficulty was adapted to their abilities (2.34 ± 0.34) and the level of perceived challenge was balanced (2.29 ± 0.68).

Moreover, subjects were aware about their attention level provided by the guidance in the game and most of them asked to repeat the experience to enhance their scores. The difference between the perceived attention level recorded before the experience and the attention score recorded from their performances was not significant. Finally, most players enjoyed the game and found it engaging (3.33 ± 0.43).

CONCLUSION

We presented in this paper Keep Attention, a serious game designed to assess visual attention and to personalize the training experience to children. The objective of this game on one side is to help tutors to get quantitative data about children attention abilities in order to prevent attention decline and diseases. On the other side, the game may be played by children with different attention abilities, including players with attention deficits or troubles, to provide them with a personalized experience according to their training needs.

We focused on a task-oriented design framework that considers that the training objectives are independent from the game elements. This design framework helps us to develop various game worlds that are personalized to players. In particular, the personalization concerns the training tasks by dynamically adapting their difficulty according to players' performances in the assessment exercises and during the game. It also allows balancing dynamically the game goals between learning and fun according to the players' progression which may increase their engagement.

The results of the primary pilot experiment show that the players find the game personalized to their abilities. It will be important to study in future work, the effect of the serious game on players' attention with a large number of participants. We will evaluate, in particular, the personalization technique and the effect of dynamic goal settings on players' learning and motivation.

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