Development and User Satisfaction of "Plan-It Commander," a Serious Game for Children with ADHD

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Abstract

The need for, engaging treatment approaches within mental health care has led to the application of gaming approaches to existing behavioral training programs (i.e., gamification). Since children with ADHD tend to have fewer problems with concentration and engagement when playing digital games, applying game technologies and design approaches to complement may be a useful means to engage this population in their treatment. Unfortunately, gamified training programs currently available for ADHD have been limited in their ability to demonstrate in-game behavior skills that generalize to daily life situations. Therefore, we developed a new serious game (called "Plan-It Commander") that was specifically designed to promote behavioral learning and promotes strategy use in domains of daily life functioning such as time management, planning/organizing and prosocial skills that are known to be problematic for children with ADHD. An interdisciplinary team contributed to the development of the game. The game's content and approach is based on psychological principles from the self-regulation model, social cognitive theory and learning theory. In this article, game development and the scientific background of the behavioral approach are described, as well as results of a survey (n=42) to gather user feedback on the first prototype of the game. The findings suggest that participants were satisfied with this game and provided the basis for. Further development and research to the game implications for developing serious games and applying user feedback in game development are discussed.

Keywords: e-mental health; serious game development; ADHD; children.

Digital approaches have been increasingly applied to support and improve primary care processes in mental health care and are often referred to as e-mental health.[1,2] Clinicians and educators are interested in applying game technologies and game design approaches (e.g., serious games) because of their potential to increase patient engagement with existing behavioral training programs.[3] Game elements that increase patient engagement in therapeutic activities have the potential to increase the effectiveness of neurocognitive training and behavioral learning in different domains of functioning for patients being treated in mental health care.[4-6]

Game design and approaches are seen as a natural tool to make existing training and therapeutic programs more appealing to young patients with ADHD for several reasons. First, it is well known that children with ADHD experience motivation deficits and react differently to rewards compared to typically developing children.[7,8] Because game approaches help to balance motivating and learning elements and integrate game goals and behavioral/cognitive challenges, they have the potential to keep these children more motivated and positively engaged in therapy processes.[9-11] Also, despite their poor attention span, distractibility and difficulty staying on task, children with ADHD often show sustained concentration and engagement when playing digital games.[12] Therapeutic goals that are pursued in the context of an engaging game environment thus present the opportunity to improve behavioral learning and outcomes in this population.

A large number of gamified training programs for ADHD have been designed to improve working memory and executive functioning thereby addressing specific neurocognitive deficits.[13-16] While these programs show some evidence for short term effects on targeted working memory outcomes, as measured by neurocognitive tests that are similar to the ones presented in the games, they have not shown compelling evidence that these effects generalize beyond neurocognitive outcomes to important domains of functioning in the every day lives of children with ADHD.[13-16] The core symptoms of inattention, impulsivity and hyperactivity among children with ADHD are related to their difficulties in executive and social functioning in their daily lives. These problems include difficulties managing time, keeping deadlines, planning/organizing schoolwork and making friends.[17-20] These executive functioning and social problems not only affect daily life for the children and their families, they also predict a poor prognosis of ADHD even into adulthood.[20] Gamified interventions for children with ADHD that address the current difficulties in daily life functioning thus have the potential to not only tackle difficulties in the short-term but in the long term as well. While the research on gaming approaches to addressing daily life functioning of children is limited, several controlled trials of serious games developed for other patient groups have been shown promise of impacting "real world" behaviors.[21]

In addition to the importance of designing a serious game intervention to impact important outcomes that support their functioning in daily life, the intervention itself needs to be designed to be effective and engaging in order to ultimately have an impact. Previous studies provided evidence that gamified interventions based on theoretical concepts tend to be more effective than those without a theoretical framework.[22] Integrating appropriate behavioral theories into the design of the game is an ongoing challenge for serious game designers but is a key to its ultimate success.[23] The focus on integrating behavior change theories and therapeutic content in serious game design needs to be balanced by technology acceptance through the target audience of children with ADHD and their parents who will likely play a key role in accessing, facilitating and monitoring the use of the serious games technology. A broad body of evidence has shown that the success of Information Technologies (IT), such as serious games, depends on user beliefs and attitudes about the technology (e.g., "The game performs reliably and it is easy to interact with this game") as well as their behavioral beliefs and attitudes about using the system (e.g., "This game helps me understand how I can plan and organize my time").[24] Gathering this information is an important part of the development process to provide an intermediate evaluation of design decisions and a basis for major or minor design decisions to promote the success of the product.[25]

In this study, we describe the development process of a serious game we developed for children with ADHD that encourages behavioral learning and promotes strategy use in important domains of daily life functioning, namely; time management, planning/organizing and prosocial skills. We also present results of a user satisfaction survey we conducted on a pilot version of the game.

Theoretical Basis for the Serious Game Intervention

We developed a serious game called "Plan-It Commander" for a target population of children with ADHD aged 8 to 12 years. The therapeutic behavioral learning objectives of the serious game were to promote the use of strategies in important domains of daily life functioning, namely time management, planning/organizing and prosocial skills. These behavioral objectives were translated into a suitable game based on relevant psychological theories such as, (1) the self-regulation model,[26] (2) social cognitive theory[27] and (3) learning theory.[12,28]

"The self-regulation model of health and illness behavior focuses on how individuals direct and monitor their activities and emotions in order to attain their goals.[12,26] Children with ADHD often lack self regulation and as a consequence, they master skills at a lower level. In addition, they feel incompetent about their performance and think that they can not cope with situations in which these skills have to be used. The serious game

contained components that helped them direct and monitor their activities (e.g., predict how long it would take them to complete a "mission"), regulate their emotions (e.g., slow down to help other characters in the game in order to "win"), and practice as many times as needed in order to reach mastery (e.g., no overt or explicit penalties for "mission failure"). Components such as these were explicitly built into the system to provide a safe environment to practice skills that could be applied in their daily life.

The serious game also included elements from social cognitive theory.[27] According to this theory, children's learning is influenced by interactions between the environment, personal factors and behavior. The environment supports mastery of target behaviors by providing models for target behaviors and positive support for behavior change. This theory was translated into the game by offering children with ADHD structured behavioral goals to reach in the game (e.g., collect minerals with the time that you estimate it will take to complete the task). These goals were presented in an environment that included a virtual mentor figure who was a model of positive behavior (e.g., polite in social interactions) and also provided emotional encouragement and positive feedback for success and multiple opportunities to practice behaviors to reach mastery. The game environment also included a social community in which peers (other children with ADHD) could interact with each other. Players could also directly or indirectly benefit from positive reinforcements they observed others received or that they received directly as a result of their own successful efforts to reach goals in the game. The concepts of vicarious learning, emotional support, provision of mastery experiences are key components of behavior change in social cognitive theory,[27] that were implemented in the game design.

Lastly, principles of learning theory were incorporated in the serious game. Learning theories are based on the general idea that individuals learn behavior through behavioral consequences and positive reinforcement.[12,28,29] Children with ADHD are less sensitive to negative feedback and learn the most through repetitive positive feedback. In this game we immediately reward positive behavior, based on this principle. As a result, extensive practice of desired behaviors is stimulated".

Collaborative Game Development

Interdisciplinary collaboration is a key factor in developing a serious (either educative or therapeutic) game, as different expertise from various areas (clinical, research, technical and game design) needs to be integrated.[23] Therefore, different parties (i.e., sponsor, game development company, health care professionals, researchers, parents and children with ADHD) were involved in the development of the "Plan-It Commander" game. In collaboration with a community board of parents, the learning goals (e.g., time management,

planning/organizing and prosocial skills) were proposed by health care professionals based on scientific literature and practical clinical experience. Furthermore, these professionals provided input on the game goals and advised the game designers on how to give feedback to children with ADHD. Frequent interactive sessions between the behavior experts, researchers and game designers took place to optimize the link between game elements and the principles of behavioral intervention, allowing game designers to gain additional expertise and knowledge to develop an attractive game that "works" for this target population.[23]

Results of important deliverables and milestones were presented to the advisory board consisting of professionals familiar with the content of gaming, research and clinical practice. Researchers were involved to design and set-up research trajectories to test game usability and effectiveness. After each prototype, usability tests were iteratively performed to examine whether children liked the game, and understood how to use it and navigate within the game. These user data were evaluated and incorporated in the design process. Parallel to testing the first prototype in a pilot study, the game was further developed and extended resulting in the final version of the game described in this article. The stages of game development and evaluation are illustrated in Figure 1.

Figure 1 around here.

Game Description

"Plan-It Commander" is an online computer game with a futuristic and adventurous character consisting of two parts: (1) the mission game; a game environment with missions and three isolated minigames with embedded learning goals and; (2) a closed social community for interaction through predefined messages. Each minigame has levels of increasing complexity and performance challenges. In the game the player is a space captain undertaking missions assigned by his mentor who guides the player, gives him/her feedback and helps wherever he can. The player's goal is to collect and recover rare minerals. Characteristics of "Plan-It Commander" are described in Table 1.

Table 1 around here.

To motivate and engage children throughout the game a number of special features were designed (see Table 2 and Figure 2).

Table 2 and Figure 2 around here.

Missions and side-missions

The game is divided into ten different missions and several side-missions. Missions guide the player's behavior throughout the game as they follow the story line and are confronted with assignments requiring specific skills to solve problems. Completing these assignments ensures skills concerning time management, planning/organizing and prosocial behavior are practiced and trained. Each mission has different tasks and the player has a mission board to check which missions he/she has completed. Once a mission is completed the next mission becomes available. Side missions are independent missions, separate from the main storyline and are optional. Several side-missions focus on triggering player's prosocial behavior, e.g., players can ask other players for assistance (e.g., finding special items) and in turn decide whether to provide assistance. In addition, players can make short-term and long-term agreements with other non-playable characters (NPC's), e.g., to retrieve items. Further general learning goals throughout the game include; listening to the mentor, dealing with frustration, ignoring distraction, learning to concentrate, being attentive and inhibiting impulses.

Minigames

A minigame is a small, isolated game within the larger game environment that integrates unique game elements offering tools to improve strategic behavior. Players begin with an explanatory tutorial level and progress through the game by accomplishing levels within the minigames and missions. Three minigames with assignments addressing time management, planning/organizing and prosocial behavior are embedded in the game (Figure 3).

Figure 3 around here.

Minigame 1: Labyrinth

Within this minigame the player learns to manage time and to estimate time needed. In addition, players learn that it may be helpful to break down an assignment into pieces or to relax before making decisions. The labyrinth

game is divided into two different parts. In the first part the player collects minerals in a maze within a limited time frame. In the second part the player estimates the time needed to collect all the minerals. In both parts of the game several strategies can be used to optimize performance, such as; 1) player planning optimal route on a map before entering cave, 2) clicking on clock to check time and 3) using the so called "safe zones". In these zones time pauses so the player can plan his/her next move or just relax. The player has to collect minerals whilst facing distractions in the maze, thus learning to keep the main goal in mind. For both parts of this minigame there are six different levels, increasing in difficulty. A level is completed when the player collects all the minerals within the restricted time frame or when the player finishes on time i.e. within his/her estimated time frame.

Minigame 2: Explorobot

Players learn to plan ahead and break down the total assignment into pieces. The player has to collect several minerals which lay scattered in a sewer, using robot Ico. The player determines the shortest route for Ico and then gives Ico this route description by means of a series of commands. If the player makes a mistake in planning the route all commands will be deleted and the player has to plan the route again. As a strategy to optimize performance, players can use checkpoints. If a player makes a mistake after a checkpoint, the robot will jump back to the last checkpoint and the route can be adjusted from there on. The player can choose to use a limited amount of checkpoints per level. In total there are 51 levels of difficulty with several tutorial levels. As it may be too hard for some players to find the ideal route, a margin is determined, which is the number of steps needed for the optimal route plus 30% (with a maximum of 10 steps). A level is completed when the optimal route (i.e., minimum number of steps) is planned for Ico.

Minigame 3: Space Travel Trainer

Here players learn to help their team members and to behave in a more prosocial manner towards others. The player flies his/her space ship from planet to planet to reach the target planet with three team members. These team members (named Nika, Vesto and Kortar) are not real players but are computer generated, and called NPC's. The team members depend on the player when handling obstacles such as a star rain, while they follow their predefined route. If the player does not help his/her team members by giving the right commands (e.g., shield, boost, cloak) in time, they inevitably get stuck with low energy levels, which the player has to replenish. Team members ask for help and express their emotions when in dangerous situations. The player can thus use

more than one channel to interact with the team members. In total there are 31 different levels of difficulty. A level is completed when all team members and the player have finished.

Social community

To stimulate prosocial behavior, a social community was developed in which game players can see each other's profiles and space ships and communicate with each other through predefined messages, for example with a 'thumbs up' or 'thank you' button (Figure 4). In addition, players can see each other's rank and current mission status. This aims to stimulate game play and generates some competition between players.

Figure 4 around here.

Achievements are related to the learning goals of the intervention and to rewarding players for prosocial behavior within the social community, such as helping other players or giving compliments.

Acceptance and Usability Study

The initial prototype had three minigames focusing on time management, planning/organizing and prosocial behavior. The player's mission was to collect as many minerals as possible. The above mentioned social community, missions, side-missions and special features had not yet been developed. From October 2011 to March 2012 a pilot study was conducted to test the feasibility of conducting a randomized trial on the full game. As part of the pilot study, participants also filled out questionnaires designed to assess acceptance and usability of several game elements. Acceptance and usability were assessed to inform design decisions for further development of the game to a final version to be evaluated in a randomized controlled trial for outcome efficacy.

Participants

Candidates for the pilot study were identified and informed by their therapist. The therapists were all members of the consortium consisting of ADHD specialized mental health care services. Once a potential participant was identified, children and parents received information letters from the researcher, allowing them to make an informed consent about voluntary participation in the pilot study. Inclusion criteria were (a) having a clinical DSM-IV-TR ADHD diagnosis (all subtypes were included) set by a certified health care professional, (b) aged between 8 and 12 years, (c) being stable on pharmacological and/or psychological ADHD treatment for at least

two months prior to baseline assessment (determined by health care professionals on the basis of medication data and behavioral observation) and (d) availability of a computer workstation at home with internet and sound facilities. Children were excluded if they had an estimated total IQ of 70 or lower and had a physical and/or cognitive disability (i.e., deafness, blindness) that would predict great difficulties in playing the serious game and would be problematic for standardized measurements.

In total, 66 children were referred by their therapist and informed about the studies' purposes. The final sample consisted of 42 clinically referred children with a primary diagnosis of ADHD. Children's age ranged from 8 to 11 years with a mean age of 9.4. Children participating in the study had average intelligence (M = 104; SD = 12.3). This was tested with the Wechsler Intelligence Scale for Children III (WISC-III) short version.[30] There was an absence of any neurological disorder, sensory (blindness, deafness) or motor disorder as stated by the clinicians and parents. All children except for two were taking ADHD medication at study entry. Comorbidity of dyslexia was present in four children.

Procedure

As part of the pilot study we decided to randomize children to one of the two conditions for playing the "Plan-it Commander" prototype. Twenty children were asked to play the game for a maximum of three times per two weeks (total number of play sessions M=7.41; SD=1.37) for six weeks. Twenty-two children were asked trying to play the game about eight times per two weeks (total number of play sessions M=17.16; SD=4.75) for six weeks. However, as there appeared to be no significant differences ($p > .05$) among children's and parent's satisfaction scores between the two groups we decided to present the results of the total group of children. Children played the game at home for eight weeks, divided into four periods of two weeks, with a free choice in playing one of the preferred minigames during the last two weeks. Every two weeks a different minigame was unlocked in predefined order. Children had their own password and ID to log on from their home. Children were asked to play the game for a minimum of 30 minutes and a maximum of 45 minutes each time. Two children were lost to follow-up and one child dropped out because of acute psychiatric problems. Ethical approval was obtained from the Committee of Medical Ethics for Mental Health Care in Utrecht. Written informed consent was obtained from both parents. Questionnaires were developed especially for this study to assess expectations and satisfaction. Parents filled out questionnaires measuring expectations at baseline (pre-test measurement; see Appendix 1) and satisfaction at follow-up (post-test measurement; see Appendix 2). Children filled out a

questionnaire at follow-up to assess their satisfaction with the prototype "Plan-It Commander" game (see Appendix 3).

Pre-test parent expectations

Parents rated their expectations about the game in different domains during pre-test measurement (Table 3). Ratings were collected on questionnaires specifically designed for this study (Appendix 1-3). Questionnaires were filled out at study location on a laptop. Questions included, "How much improvement do you expect with regard to the time management skills of your child?" Parents rated their answers on a 10-point Likert scale in which 1 = "none" and 10 = "a lot". Scores from 6 to 10 were combined and interpreted as a positive response. As shown in Table 3, parents had overall high expectations of the game, except where it concerned learning prosocial behavior and reducing ADHD core symptoms. This might be explained by the fact that parents feel prosocial behavior is hard to target in a game. Learning prosocial behavior through a game requires multiplayer options and a different game structure than proposed in this first prototype.[31] For these reasons, a social community aspect was integrated in the final version of the game. Furthermore, the game was not focused on diminishing ADHD core symptoms but on improving behavioral skills. Therefore, lower expectation scores regarding this topic reflect a realistic insight into the capabilities of this game intervention.

Table 3 around here.

Post-test parent satisfaction

At post-test measurement parents answered four additional questions on a 10-point Likert scale (1 = "not at all" and 10 = "totally") concerning parental perceptions about the burden of playing the "Plan-It Commander" game on the child and family. Mean scores ranged from 2.5 to 4.3, indicating that most parents did not feel offering such game intervention was troubling for the family. Furthermore, results demonstrated that parents were overall positive about the game. Their average overall satisfaction with the game was 6.7 (SD = 1.4; on a scale from 1 to 10). In addition, a majority of the parents (88%) reported they would recommend the game to other parents. All parents (100%) indicated (on a yes/no question) they would like access to the game once further developed. These findings assured us that our current approach was acceptable for parents and helped us in deciding on how and to which degree children should be exposed to the game.

Post-test child satisfaction

We also asked the children who played the game to rate their game satisfaction in different areas (see Table 4). Ratings on 7 questions were collected on a paper-and-pencil questionnaire specifically designed for this study (see Appendix 3). Colours and smileys were used to highlight the different answer categories on a 5-point Likert scale (1 = "not at all" and 5 = "very"). Table 3 shows the number (%) of children who gave a positive opinion (i.e., a combination of the two highest scores) on the satisfaction questionnaire. While only, 44% of the children indicated they were motivated to play the game, 67% of the children indicated they had learned from the game and 77% were positive about making the game available for other children with ADHD. A social community, several side missions and special features were added to the "Plan-It Commander" prototype making it more attractive and thereby more motivating and challenging for children. This is relevant as motivation is thought to be an important mediator for changing behavior.[6, 31-33]

Table 4 around here.

Qualitative user-experience

At post-test measurement, both parents and children answered open question concerning changes to the game. They provide useful suggestions and recommendations for improvements, such as requests by children for more characters, travel to different planets and other characters in the game world. Some parents indicated the game could be more challenging for their child, especially if they already had broad gaming experience. These important responses and feedback were very supportive in finalizing the full game.

Summary and future perspectives

In this article we outlined important aspects of developing a serious game to impact daily life functioning of children with ADHD. We described how developing a serious game is a collaborative project between various experts and users and how that process was carried out in this project. We outlined the theoretical basis for het game as a therapeutic intervention and described how the theory was implemented in various game components. This was followed by a description of the minigames and structural components of the game in which game components were embodied. The information we provided supports the need in the literature on serious games to provide detailed descriptions on the game themselves, theories that guide them and the components of the game intended to change behaviors that lead to intended positive outcomes. The

information provided is also valuable as a description of a method and approach that represents a significant effort to move beyond serious games aimed at improving neurocognitive functioning, but functioning in important domains of daily life for children with ADHD. The description of our development process was supplemented by a presentation of results for parents and child acceptability and usability ratings of a prototype of the game. We discussed the findings in light of their implications for game development.

Overall, the usability findings indicated positive acceptance of this game intervention by children with ADHD and their parents. These preliminary results, based on a prototype version of the final game, directed further development of the game by including several aspects children proposed themselves (e.g, travel to other planets, more characters, special features). Parent's feedback also helped us in making well-informed decisions about children's play frequency. The advantage of our survey questionnaire approach compared to a more qualitative approach such as a focus group is that the opinions from larger groups of people can be summarized in standardized way through ratings. A drawback to this approach is that we may have lost the opportunity to gain some important opinions and feedback from participants due to the structured format of the questions and responses. We did however also include open-ended questions, which allowed participants to provide their feedback in a less structured approach.

Both parents and children were quite satisfied with the first prototype and indicated they would recommend the game to other parents of children with ADHD. As parents' high expectations might have influenced their ratings, further research should try to control for these expectations by including teacher ratings, blinded measures and more objective measures such as neuropsychological tasks. In the current study, only two children did not use medication as their treatment as usual. It may well be that medication use is a necessary condition for optimal learning from the current intervention. Future research could examine the effects of this game in a non-medicated sample to further explore the necessity of medication as treatment as usual. With regard to development, it should be considered to extend the game or to create an add-on with different learning goals relevant for different age groups. Games could be made more individualized by creating the option to choose learning modules to suit individual developmental trajectories. This project has created a platform from which future goals could be implemented.

Although these first results regarding expectations and satisfaction are promising, a randomized clinical trial is necessary in order to test the effectiveness of this serious game. As serious games become more popular within mental health care, more research is needed on the implementation of such e-mental health interventions into the primary process of care. This game format presents an alternative to traditional behavioral interventions

currently available for children with ADHD that are often presented in school settings by therapists, making them time consuming, costly and less accessible compared to digital tools.[34-36]

In sum, the description of the approach and process used in developing Plan-It Commander along with the usability findings that led back into the development process provide an example for developing serious games for similar target groups and outcomes. The findings have implications for defining and describing the complex processes of designing and developing serious games that involve collaborations between diverse stakeholders groups that include structured input from target users and family members.

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- Helga van Oers and Annik Willems are paid employees from Janssen Pharmaceuticals.
- Rens van Slagmaat is a paid employee from RANJ serious games.
- Kim Bul has been paid by Janssen Pharmaceuticals for consultancy and lectures (fees were paid to the institution).
- Athanasios Maras has been paid by Janssen Pharmaceuticals for consultancy. Athanasios Maras has been a consultant to/member of advisory board of/and/or speaker for Janssen Pharmaceuticals, Eli Lilly, Eurocept and Neurim Pharmaceuticals, in the past 2 years and is not an employee or a stock shareholder of any of these companies. He has no other financial or material support, including expert testimony, patents, and royalties.
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