The Playability Evaluation of Virtual Baby Feeding Application

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Abstract—**This paper describes the playability evaluation of serious game application, which has been developed to significantly improve a new parent's understanding and treatment of infants with feeding disorders. Feeding problems and the associated crying are a major cause of anxiety in new parents and substantial time and effort is spent by health care visitors in helping parents to tackle these issues. In this paper, the insights from the design and implementation of the application are provided. The engagement of users and their emotional immersion are discussed. Main findings of application evaluation are presented.**

Keywords-infant feeding difficulties; virtual reality; serious games; user studies;

I. INTRODUCTION

The nourishment of the child is an important part of the role of a nurturing parent. The early feeding experience, both for young infants and their parents, is important in terms of the development of their relationship and in terms of the psychological development of the child. A great deal of the earliest interaction between parents and child takes place around the process of feeding. Feeding, therefore, has more than just a nutritional function even at the earliest stages in a child's development, it is important also in the establishment of the relationship between the caregiver and the child [1]. From a parents perspective the feeding situation can become a measure of how successful they see themselves as parents. It can be an overwhelming and confusing experience for new parents, even in the absence of any problems. Around 20-25% of parents report feeding difficulties of some sort in the first two years [2].

One of the common problems is when the infant is not willing to take in as much food as the mother believes they need and she feels anxious about consequences for the infant's health and growth [3]. According to [4] approximately 25-40% of infants and small children actually struggle with feeding themselves. For a young child, a feeding disorder typically stems from a fear or mistrust of food. The child may have had a dramatic choking incident, or a delayed introduction to solid food, or simply a dislike of certain food textures in their mouth. This in turn can produce anything from a commonly fussy eater, to a less common feeding problem. Eating Disorders are serious emotional and physical problems that can have life-threatening consequences.

The treatment methods combine a specific psycho-educational intervention with parent training. The goal is to change the parent's perception and interpretation of an infant's behaviour through the therapist explanation, discussion and questionnaires [5]. It is unlikely that a single treatment would be effective across all infants. To prevent from more serious feeding problems, the treatment may include parent training, nutrition education, interaction coaching and suggestions for presenting and preparing food [6]. Traditional Cognitive Behaviour Therapy (CBT) might require modification to be effective. It is not the optimum therapy for all psychological problems and it is not accessible to all clients. There might be several problems, when the therapist is stressed by the complexity and the demands of the therapy and the case seem never-ending [7]. Another problem with the therapy may be the considerable time and effort spent by health care visitors with parents in helping them discussing their feeding issues and concerns.

The role of feeding and eating is central in a child's development; therefore any disturbances in feeding and eating are not only a problem of the individual but whole family [8]. There is a need to change the parents' attitudes and seek for effective change in their behaviour by training. There are several interactive systems, which are aimed for training and educating of users to provide them with new possibilities [9]. Interactive gaming interfaces increasingly become a common part of life. They are becoming more social and are beginning to engage people in physical activity and help them change their lifestyle and attitudes [10]. To obtain the effective change in users' behaviour, the game needs to be able to provoke some emotional responses such as fun, satisfaction and desire to improve the performance by providing emotional engagement [9]. Emotion plays an important role in decision-making, planning and action; moreover, the player interaction itself involves and requires responsibility for making choices within the game [11].

II. HEALTH AND MEDICINE GAMES

A serious game is an interactive computer application [12], with or without a significant hardware component, that:

- Has a challenging goal
- Is fun to play and/or engaging
- Incorporates some concept of scoring
- Imparts to the user a skill, knowledge, or attitude that can be applied in the real world

The game enables experience, but it is not the experience. This experience is created by player, when he

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interacts with the game. Therefore, game designers are concerned only with what seems to be true in the world of subjective experience [13]. The player puts their minds inside the game world, which only exists in their mind.

According to Bryan Bergeron [12] health and medicine games have a great impact on society and individual well-being. Many of them can be found on the Internet providing users with a strong experience and encourage them to learn how to keep healthy lifestyle, enhance self-acceptance or fight against serious illnesses. Serious games are widely used for many teaching purposes. Kelly et al [14] developed a serious game Immune Attack for teaching immunology with realistic 3D depiction of biologic structure designed as a first person shooter game, where a player explores a new territory and fights against bacteria. Other games that show encouraging results are games developed for upper limb motor rehabilitation [15] or to support triage training [16]. Beside the important user input there is an interactive 3D environment with small part of a game being put to use. Almost everything, which requires the knowledge base, skills or decision making, may be set into the interactive virtual environment to achieve considerably effective results [17].

Practical training courses for learning and simulations can be used to deal with phobias i.e. social phobia [18], acrophobia [19], fear of public speaking [20], post traumatic stress disorder [21], fear of flying [22], spider phobia [23], and treatment of eating disorders [24]. Situations which are created in a virtual environment need to be sufficiently similar to real world situations for successful patient exposure therapy. The significant advantage of this environment is that it is more controlled and cost-effective and it allows therapists to create many and varied situations and environments for patients which are not life threatening for them.

III. APPLICATION OBJECTIVES

The objective of our work is to design solutions for parents to significantly improve their understanding of infants with feeding disorders. We focused on creating everyday feeding situations to provide users with an environment which requires skills improvement to achieve better task performance. During the application development process, we identified several key research challenges:

- Game design – develop a game based on real situations and problems, which beside the educational character provides users with fun and motivation to play again.
- Character design – create a believable child character with movements and reactions accepted by users, see Fig. 1.
- Decision system – system of rules and recommendations that guide the user to a more efficient learning process, to accompany the learner in discovering of the required knowledge.

One of the necessary steps to create a good game design is to define learning goals and objectives [14]. They were created based on developmental sequence of skills and common feeding difficulties of infants [8] in collaboration with psychologists who are focused in this problematic area. On the basis of the learning objectives, we identified a game play strategy to support these objectives, see Table 1. The game play requires players to be active and precise in observation of the baby's movements for better estimation of its reactions and to use this knowledge to perform the task easier and success even when the baby's mood is changed.

Figure 1. Positive baby's reaction with information displayed on the screen

TABLE I. LEARNING OBJECTIVES SUPPORTED BY THE GAME

Learning objectives	Game support
The coordination of the spoon movement with baby's movements and learning of different feeding techniques.	Set of rules covering the baby's behaviour and reactions
The user learns to estimate baby's reactions.	Adapted but accurate baby's movements based on observations of real infants
The user learns how to deal with different baby's behaviour and is able to observe differnet baby's reactions during feeding.	Tha baby's mood may be controlled by changing of values of individual parameters.

IV. APPLICATION ARCHITECTURE

Fig. 2 shows overall architecture of the Virtual baby feeding application. It consists from user, application environment and three components; User input, Intelligent decision support (IDS) system and Output feedback, which form the interface between the user and the environment. From the user perspective, it is necessary to interact with the system through the input device according to output feedback

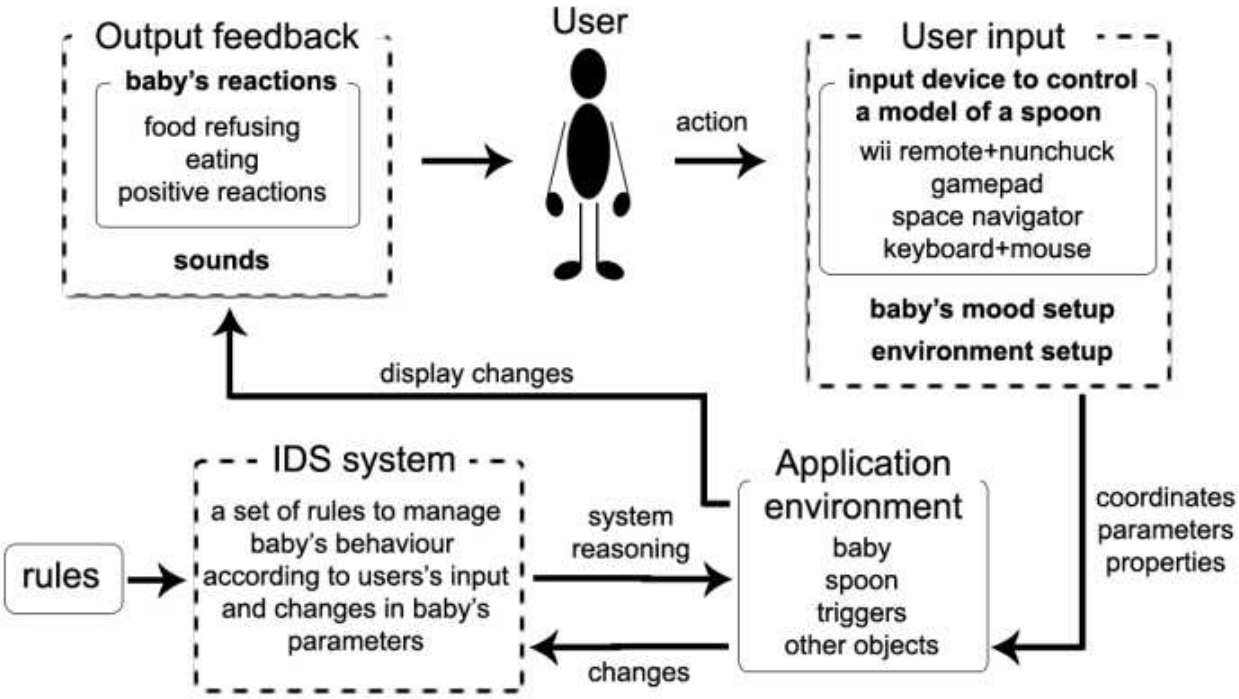

Figure 2. Architecture of the application

User input: The user interacts with application by using the input device and setting up the environment and the initial parameters of baby's mood through the keyboard. Characteristics and behaviour of objects in the environment are affected by the user's input. Controlling of the spoon changes its coordinates according to which the parameters of a child influencing its behaviour are adjusted. The Wii remote with nunchuck, gamepad, space navigator or keyboard with mouse can be used as the input device.

On the basis of observations made during the lunch time in the nursery in collaboration with child care professionals five parameters characterising the state of the child were identified and the most typical reactions and behaviour of the child were clustered. The baby is at the beginning in the default or chosen state characterised by different values of parameters. According to different combinations of parameter values and user's input acting, the model of baby expresses different facial and body expressions. The five parameters of the model of baby are as follows:

- Distraction – from the value when the baby pays attention on carer to the value when the baby pays attention on everything else except the carer.
- Tiredness – the value represents fresh and active to very tired and sleepy.
- Happiness – from very happy to unhappy and angry.
- Hunger – from very hungry to not hungry at all.
- Food – the value represents the baby likes food and wants to eat to the value when the baby doesn't like food or texture at all.

Each of the parameters has a range of possible values from1 to 5 and relationships among individual parameters are defined, see Fig.3. When the user's input causes change in one of them it influences several others. For example if the baby becomes more tired and the user still tries to feed him, the value of happiness will decrease.

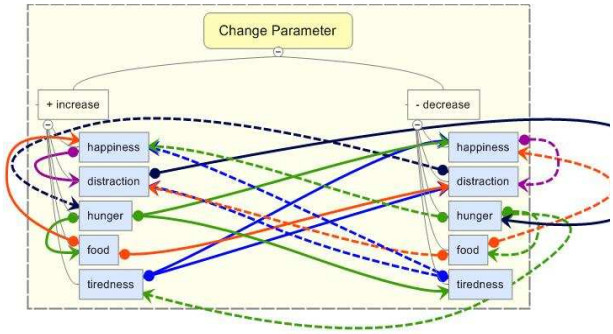

Figure 3. The scheme define relationships among individual parameters; Parameter value can be increased or decreased by the system followed by the changes in those parameter values, which have defined relationship with the original parameter shown by arows.

Output feedback: Response and action of the user are influenced by feedback from the application. It gives users an immediate clue on changes in baby's behaviour and which action is required as next. Output feedback component displays baby's animations and sounds. An example might be refusing of food and turning head aside

accompanied by hand movements and sound expressing dissatisfaction or tiredness, see Fig. 4. The following user's behaviour and the extent of the emotional affection depend on the baby's reactions. Values of parameters, information about the baby's behaviour and additional hints, advices or positive reinforcement can be displayed or hidden on the screen. The output depends on implementation of IDS system.

Figure 4. Negative baby's reaction with information displayed on the screen

IDS system: IDS system is a component, which monitors changes in the application environment and based on rules manages the system reasoning. Depending on changes in the spoon movement and position controlled by user and the current values of parameters system decides on the response of the baby and makes changes in parameter values. This component determines what will happen at any point in time. The basic idea of IDS is that with the help of experts' knowledge and definition of the problem it can specify the steps by which a problem may be solved and can explain in detail the reasoning that led to a certain conclusion. This increases the confidence that the correct decision is made. The cost of providing expertise per user is greatly lowered and the system can respond quickly or in real-time and be more available than a human expert [25].

IDS may also act as an intelligent tutor by letting the user run sample examples and explaining the system's reasoning while executing so that it is understandable to the user. The system is necessary to be flexible, be able to adapt to upcoming changes and evolve with changes in technology [26]. One of the important features of the decision support system is that user can make as many mistakes and ask as many questions as possible without causing any life-threatening situations and problems. It may be a great interactive tool for prevention, which provides parents with feedback.

V. USER STUDIES

The In this research, we conducted a study attended by 33 participants. There were 13 females and 20 males with a mean age of 27.8 (20 to 58 years old). The task for each participant was to feed the virtual baby. One feeding represented a mini-game with two possible endings; the baby was either not hungry anymore or too tired. Successful feeding consisted of inserting the spoon into the baby's mouth several times. Each participant completed five such tasks, which varied in baby's happiness posing a difficulty of the mini-game. Once during the five times participants could see information about the parameters, described baby's behaviour and some hints on how to perform the task better displayed on the screen. First controlling of the spoon was demonstrated to the user and they could try controlling by themselves. After playing, everyone filled out the questionnaire based on Heuristic evaluation for playability [27].

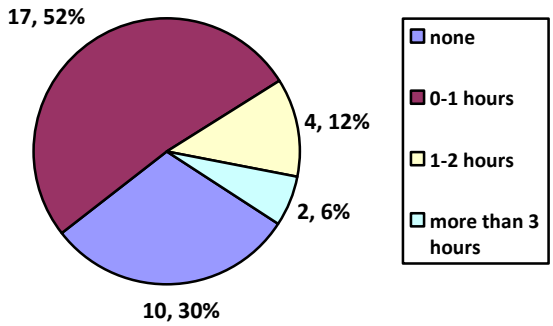

Figure 5. Hours per day spent using computer games

Only 4 participants had their own children, but 14 participants reported that they had already fed a baby, i.e. the friend's or sister' baby, younger brother etc. 7 users worked in the Nursery as child care professionals. 36% of users never fed a baby. Most of players (almost 82%) have not played games at all or only up to one hour per day on average. 6 participants spent more than an hour a day using computer games, see Fig. 5.

A. *User engagement*

It is important to engage the user in problem-solving activities, rather than passively digest course content. Problem centred training helps to increase motivation and compels users to think about, organize and use information in ways that encourage active construction of meaning and understanding of the problem [28]. The participants rated the game as enjoyable to replay 2.9 in average on 4 levels Likert scale with 1 representing not enjoyable and 4 representing enjoyable. Most of them (78,8%) identified the game experience as positive; 12 participants rated the experience 4 and 14 participants by 3 on 4 levels Likert scale with 1 representing negative and 4 representing positive. More than 60% of users thought that the game experience relates to the real life and grabs their interest.

B. *Usability study*

The game designer needs to provide players with sufficient difficulty to make them feel challenged but also provide activities to achieve a satisfaction [29]. The participants did not find the task too easy. The average rating of the difficulty level of the task was 2.7 from 4, where 1 means very difficult. The game goal was clear, over 63% of players preferred game mode, which showed them information about the baby mood and related hints. Especially, they considered offered advices and hints, like

where and when to navigate the spoon, as very helpful in better task performing, see Fig. 6.

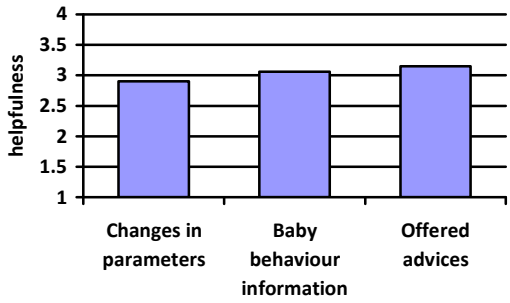

Figure 6. Helpfulness of different information displayed on the screen

15 users expressed agreement and 14 users strong agreement that information on the screen and a short training helped them to better perform the task.

C. *Emotional immersion*

To explore users' emotions and feelings of the personal involvement in the game, we created a list of options describing the emotional mood of user. We found that there is an emotional connection between the player and the virtual baby.

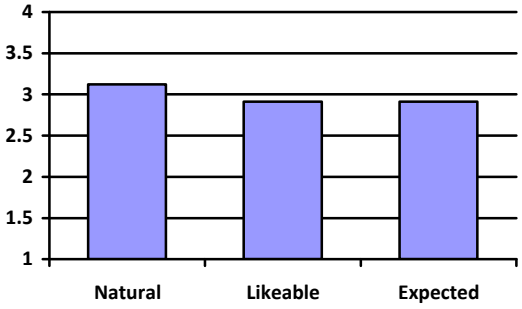

Figure 7. Rating of baby's sounds

Over 60% of the participants felt happy when the baby ate food, more than 42% enjoyed the baby's reactions. 8 participants felt stressed when the baby refused food and 3 of them were worried about the baby. One participant felt uneasy because of sounds and only 4 participants reported that they did not feel anything from mentioned, especially one indicated that it was not real enough to make him feel anything. Two of participants who felt stressed while refusing of food mentioned that baby made them slightly angry, when refused food. 27 users either agreed or strongly agreed that sounds from the game provide a meaningful feedback or stir a particular emotion. They rated sounds on a scale 1 to 4, where 1 reflects negative opinion, see Fig. 7. Majority of people enjoyed the behaviour and movements of the baby. They mostly could expect the baby's reaction during feeding and consider movements of the baby as more natural than unnatural, see Fig. 8.

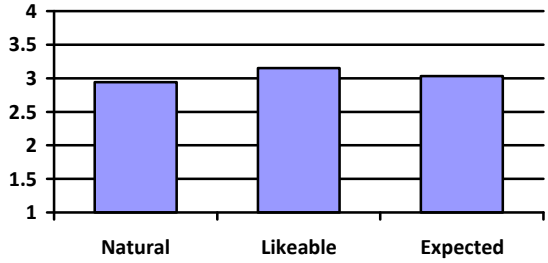

Figure 8. Rating of movements and the behaviour of the baby

VI. DISCUSSION

Participants were asked to identify the best and the worst thing about the game and to determine other possible ways of feeding or improvements to balance the game play. These questions were open-ended to elicit free responses. The most often mentioned responses identifying a positive aspect of the game were related to baby's reactions and satisfaction when the baby ate food. They reported that they felt accomplished after successful feeding and they felt personal involvement thanks to changes in the baby's reactions and sounds. Several participants, while playing the game, instinctively spoke to the baby with phrases "good boy" or "you're not hungry anymore?" and similar. One participant found himself making train sounds and another one suggested to include an aeroplane technique for a bit of fun interaction. The ability to improve with practice over time and variations in the activity played an important role in positive feedback. The most disliked aspect of the game was the difficulty in controlling of the device mainly caused by problems in hand coordination using buttons and joystick at the same time. Most participants would welcome a simpler interface. Some of them considered a picking of food up again as hard and they feared that they would strike the baby with the spoon. Participants would like to see more of baby's responses and varied sounds corresponding to reactions. Some suggested to have toys like a rattle in the environment and have the opportunity to bottle feed the baby or provide him with a cup. A few participants expected the baby to grab the bowl.

VII. CONCLUSIONS AND FUTURE WORK

We have introduced a game aimed for parents who have experienced some feeding problems with their infants. The game playability and emotional involvement of users were discussed. User testing is very important for evaluation, since a designer can never completely predict users' reactions and possible problems that might appear [27]. The development process gave us valuable experience in understanding users' needs and helped us enhance the game concept and its usability. We found that the game was highly engaging. To increase the level of engagement and users' immersion, there is need to involve more accurately baby's reactions, possibly allowing users to encourage the baby's reasoning. We believe that this application has a great potential to promote a rational use of game technology in Health Care with emphasis on the accessibility and quality of delivered treatment.

There is still need to conduct further tests to evaluate the validity of the IDS system and establish if the application does what it is intended to do. This study has allowed us to improve the controlling of the spoon and the game design to build an appropriate application for usability study with new parents and their children.

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