iCat, the chess player: the influence of embodiment in the enjoyment of a game
(Short Paper)

André Pereira, Carlos Martinho, Iolanda Leite and Ana Paiva

INESC-ID, Instituto Superior Técnico
Av. Prof. Cavaco Silva - Taguspark
2780-990 Porto Salvo, Portugal

{andre.pereira, carlos.martinho, iolanda.leite}@tagus.ist.utl.pt, ana.paiva@inesc-id.pt

ABSTRACT
This paper presents an experiment that evaluates and compares the user enjoyment when playing a game of chess in two situations: against a physically embodied robotic agent and against a virtually embodied agent, displayed on screen. The results of the study suggest that embodiment has implications on user enjoyment, as the experience against a robotic agent was classified as more enjoyable than against a virtually embodied agent.

Categories and Subject Descriptors
I.2.9 [**Artificial Intelligence**]: Robotics – *Commercial robots and applications*

General Terms
Experimentation

Keywords
Autonomous Agents, Embodiment, Synthetic Characters, User Enjoyment, Chess.

1. INTRODUCTION
Synthetic characters can be seen as agents that have an embodied representation and interact with users or other agents in an autonomous manner. These character's embodiment have usually a 2D representation [15] or a 3D representation [7], but may also have a physical robotic embodiment [20].

There is a common understanding about the importance of emotion and expressive behaviour in synthetic characters, as they lead to more natural and believable interactions with humans [2]. We studied the relevance of another attribute of synthetic characters: *embodiment*. More concretely, we studied the implications that embodiment has on *user enjoyment* in a gaming scenario that uses synthetic characters with social behavior. Understanding what makes players enjoy a game is perhaps the most important issue in successful game design [8]. Thus, the main research question addressed is: *do people have more fun using the version of our game with a virtually embodied opponent? Or have they higher enjoyment while playing against a physically embodied one?* To provide a preliminary answer to this question, we created a scenario in which the user played chess game on a physical electronic chessboard that detects the board state and sends it to the computer, against a synthetic character whose affective state is influenced by every move the player makes. One of the setups uses a physically embodied agent, the other a virtually embodied agent.

Cite as: iCat, the chess player: the influence of embodiment in the enjoyment of a game, André Pereira, Carlos Martinho, Iolanda Leite and Ana Paiva, *Proc. of 7th Int. Conf. on Autonomous Agents and Multiagent Systems (AAMAS 2008)*, Padgham, Parkes, Müller and Parsons (eds.), May, 12-16., 2008, Estoril, Portugal, pp. 1253-1256.

2. RELATED WORK
Although the literature on synthetic virtual agents is vast [6, 13, 17], the link with robotic agents is small as there are not so many situations where both virtual and robotic agents are involved or compared. On the other hand, many researchers are studying the impact of robotic agents interacting with users [9].

Pfeifer et al [18] pointed out the importance of embodiment to represent "intelligent" behavior: *"Intelligence cannot merely exist in the form of an abstract algorithm but requires a physical instantiation, a body."* In computer science, the choice to embody a synthetic character is most of the times through a virtual 2D screen representation. Some authors prefer this type of embodiment [14] because they believe that today's robots (physically embodied synthetic characters) are still not adequately embodied. The main reasons pointed by those authors are that robot's movements are yet not natural and their motors still make too much noise. Wainer's et al study [20] suggests that physical or "material" embodiment in a task-oriented setting can make a difference in perception of a social agent's capabilities and the user's enjoyment of a task. However, another (contradictory) study evaluating an embodied intelligent home character (eMuu) [1], that provides intuitive feedback in the form of conversational and emotional body language in order to investigate the influence of its embodiment (virtual and physical) and its emotional expressiveness on the enjoyment of the interaction, suggests that embodiment has no significant influence on user enjoyment.

3. APPLICATION
Computer chess is extremely popular and in certain situations it surpasses the original game, for instance by allowing a one player game against an opponent of custom strength at any time of the day. By using a Graphical User Interface the social possibilities of the game, in which both opposing players are able to interact, become limited and we cannot see hesitation or any expressed emotion on the opponent. Playing chess in its original form, with a real chessboard against a human opponent, shares the social advantages, physical controls and physical information offered by most board games. Inspired by that, we built an agent with the advantages of both computer chess applications and traditional chess, and maintained the experience as close as possible to the traditional where we face an opponent and play in a physical chessboard. Hence, the embodiment of the agent was a critical element for our chess game. In Figure 1 we display the

components of our application and their interaction. The components are: (1) an electronic board that detects the user's moves (2) the agent's embodiment which can be physical or virtual (3) an agent mind that uses a chess engine and an emotion system to determine the agent's behaviour (4) an animation module that controls the embodiment of our agent. In the remaining of this section we will further describe the first three components.

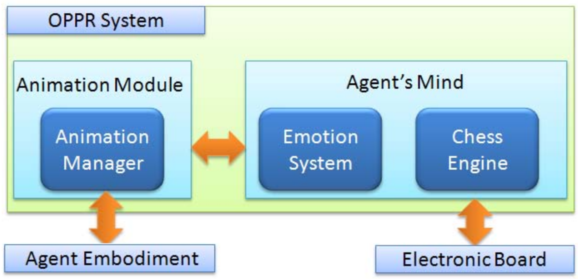

Figure 1. Game Application

3.1 Electronic Board

To maintain the physical interaction of traditional table top chess game and preserve the virtual possibilities offered by computers, we needed one chess tangible user interface to replace the virtual chessboard of computer chess applications with a real chessboard with augmented computation (electronic board). For our electronic board we used a programmable commercial tangible user interface: the DGT Electronic Chessboard from DGT Projects [5]. There is one drawback though: the DGT electronic chessboard does not have a physical mechanism to move its chess pieces. As such, the user has to play the agent's moves on the chessboard. We used speech and gestures provided from the chess playing agent in order to communicate the engine's move to the user. Initial tests showed that users sometimes needed to hear the computer's move more than once. As we did not want to annoy the users by constantly repeating the move, we connected a DGT XL clock [5] to the chessboard, using it to display the computer's last move.

3.2 Agent Embodiment

The chess playing agent must have a social component, allowing the user to understand what the agent is thinking, simulating in this way the human to human interaction of a traditional two player chess game. The natural manner used to perform these interactions is by body gestures and facial expressions. To evaluate the influence that the embodiment of the chess playing agent has on user enjoyment we used both a physical and a virtual embodiment. The choice for both the embodiments was the iCat platform from Phillips Research [3]. This platform contains a user-interface robot named iCat that is capable of mechanically rendering facial expressions and the OPPR (Open Platform for Personal Robotics).

For the physically embodied agent, we used the iCat robot. This robot uses 11 servos and 2 motors to control individual parts of its body, such as eyelids and neck. Located on the robot's front, there is a loudspeaker controlled by an internal soundcard device. The speaker is used for speech and sounds. With all these capabilities, the iCat robot can embody a social agent since it has many of the characteristics needed to simulate human-to-human interaction. As such, we chose it to embody our physical chess playing agent.

For the virtual agent we used a 3D animated version of the iCat, available in the OPPR software. With this software we are able to launch a window with a virtual iCat that behaves in exactly the same manner as the robotic one and has the same appearance.

3.3 Agent's Mind

To build a one player computerized chess game, we needed to integrate our application with a chess engine. Our focus was to make the experience of playing chess close to the real game, and we did not have the need of a grandmaster level virtual chess opponent. As such, we integrated Tom Kerrigan's simple chess engine [10] in our agent's mind.

The agent's mind is a time-based execution module created to run on the OPPR system. This module comprises the "mind" of our application, a chess game named "iCat, the Chess Player" where a user plays a chess game against an embodied social agent. The agent's sensors are the automatically updated information given by the electronic chessboard which detects the user's moves. The chess game can begin from the initial chess position or from any valid position (e.g. a chess problem). In this game, the user can take hints about the state of the game by analyzing iCat's facial expressions, generated by an emotion system. The emotion system is based on the emotivector, an anticipatory mechanism [16]. This system is triggered after the user plays his move. At this moment the agent's mind receives the board evaluation from the chess engine, processes it and updates the agent's state. The agent has two main emotional components: emotional reactions (computed after every user's move using anticipatory mechanisms) and mood (longer lasting affective state controlled by a valence variable). The affective state is then reflected in the embodied agent's behaviour, which is controlled by the OPPR's animation module, responsible for animating the iCat's body parts. In this game, if the iCat is expressing a very happy face it means that it is winning. Likewise, after every move played, iCat also gives feedback about what he "thinks". If the user plays a bad move iCat reacts with a happy animation. When this happens the user can take back the move and play another one. By repeating this process, chess can be learned by distinguishing the bad from the good moves. The complete design and implementation of the anticipatory emotion system used in this experiment is described in [11] [12].

4. EVALUATION

This section describes the preliminary experiment we performed on our chess playing agent's implementation. By measuring the user's enjoyment while varying between a physical and a virtual setup of our game we were able to answer our proposed research question. The following sub-sections will discuss the methodology involved in our experiment and the obtained results.

4.1 Methodology

In the experiment, participants had the opportunity to play a chess game against the iCat using the DGT electronic chessboard.

4.1.1 Measurements

Each participant played chess against either a physical or a virtual opponent. Our independent variable is the type of test: *physical* or *virtual*. Our dependent variable is user enjoyment, and to measure it we followed the design of an independent test where each participant only played against one of the two possible embodiments.

4.1.2 GameFlow

To evaluate our dependent variable, the user enjoyment, we chose a model designed to evaluate user enjoyment in games, the GameFlow [19] model. GameFlow is based in the Flow theory analysed by Csikszentmihalyi, stating that "*Flow experiences can be divided in eight elements and a combination of these elements provokes a sensation of deep enjoyment that people, just for the sake of feeling it, spend a great deal of energy and time*" [4]. The Flow model can be used to evaluate user enjoyment in any task, but since we want to measure user enjoyment specifically in a game we used the adaptation constructed for games, the GameFlow model. This model maps the eight elements from Flow to elements of the game literature and concludes that to have Flow (i.e. user enjoyment) in a game the elements that must be present are: *concentration* (games should require concentration and the player should be able to concentrate on the game); *challenge* (games should be sufficiently challenging and match the player's skill level); *player skills* (games must support player skill development and mastery); *control* (players should feel a sense of control over their actions in the game); *clear goals* (games should provide the player with clear goals at appropriate times); *feedback* (players must receive appropriate feedback at appropriate times); *immersion* (players should experience deep but effortless involvement in the game); s*ocial interaction* (games should support and create opportunities for social interaction).

To evaluate each one of these elements we have used and extended some criteria formulated in the GameFlow model. The "clear goals" element was removed because the only existing goal in our game is clear: to win the chess game against the iCat. Similarly to the GameFlow model, each question is a five point evaluation Likert scale where the user may choose to strongly disagree, disagree, neither agrees or disagrees, agree or strongly agree. User enjoyment is calculated by a simple mean of the seven elements' values. These elements are the dependent variables of our experiment.

4.1.3 Participants

There was a total of 18 participants, all of them knew how to play chess and had some experience with computerized chess. Since a regular chess game without time restrictions usually takes up to 2 hours or more to play, we decided to test users in a predefined mid-game position. This position gave some advantage to the user and was designed with the intention of entering early in the end part of the game. We tested our application in 2 different locations. The first sessions took place in a chess club, "Clube de Xadrez de Sintra", where we had 5 participants with the target age from 8 to 12 years old. The second location was at the Instituto Superior Técnico (Technical University of Lisbon), where 13 participants with ages between 19 and 32 participated in the experiment. After each game against our agent, participants filled up a questionnaire where an evaluation of the GameFlow elements described above was made.

4.1.4 Setting

The experiment was conducted in the two different scenarios, *physical* and *virtual*. The participants who played in the first scenario did not play on the second one and vice versa, because they would have played the same position twice and therefore compromise the results of the second experiment.

Physical Setup

In this set up (see Figure 2), participants sat on a chair in front of a table containing the DGT electronic chessboard, DGT XL clock and the Phillips iCat. Even though the player did not interact with it, the table also contained a laptop running our application, connected to the iCat robot and the electronic chessboard. In this scenario the participants played their moves on the electronic chessboard and watched over iCat's behaviour and its reactions to the same moves.

Figure 2. Physical setup

Virtual Setup

In the virtual setup (Figure 3) the iCat is virtually embodied and displayed on a 17 inch TFT computer full screen. We have chosen a 17 inch screen to make the experience as close as possible to the physical one where the iCat have a height of 38 centimeters.

Figure 3. Virtual setup

4.2 Results

In this section, we present the results of our preliminary testing sessions. Because we did not obtain a normal distribution with our test samples, all our test are non-parametric.

4.2.1 User Enjoyment – Virtual versus Physical

To study the differences in user enjoyment between the physical and virtual embodiment of the iCat, we used the Mann-Whitney U test to analyse the questionnaires. First we ran the Mann-Whitney U test using the "type of test" as the grouping variable and the "user enjoyment" as the test variable.

Table 1. User Enjoyment Mann-Whitney U Test Ranks

Type of Test	N	Mean Rank	Sum Of Ranks
Physical	9	12,1	108,5
Virtual	9	6,94	62,5
Total	18		

The columns mean rank and sum of ranks from Table 1 show that the direction of the difference in user enjoyment is physical towards virtual.

Table 2. User Enjoyment Mann-Whitney U Test Statistics

Item	Z-Score	p-Value	Direction
User Enjoyment	-2,035	0,042	*Physical* > *Virtual*

Table 2 presents the results of the Mann-Whitney test which gives us the information that we have a significant result (p-value <

0.05) and a z-score of -2,035 with the difference direction of physical > virtual. Therefore, our preliminary experiment, suggests that playing chess with a virtual embodied social agent gives the user less enjoyment that with a physically embodied one.

Why did the participants enjoyed less the virtual embodied character? To answer this question we have again used the Mann-Whitney U test but this time we made it to the seven different game elements used to calculate the user enjoyment variable. The results are shown in Table 3.

Table 3. Game Elements Mann-Whitney U Test Statistics

Item	Z-Score	p-Value	Direction
Concentration	-0,536	0,605	*Physical* > *Virtual*
Challenge	-0,461	0,666	*Physical* > *Virtual*
Player Skills	-0,946	0,387	*Physical* > *Virtual*
Control	-0,409	0,73	*Physical* > *Virtual*
Feedback	-2,249	0,031	*Physical* > *Virtual*
Immersion	-2,114	0,04	*Physical* > *Virtual*
Social Interaction	-2,184	0,031	*Physical* > *Virtual*

Feedback, Immersion and Social interaction values are significantly higher in the chess game setup that uses a physical embodied agent than with the setup that uses a virtual one.

5. CONCLUSIONS

We implemented a chess playing application with two different setups. The first setup comprised the iCat robot as the physical embodiment for our chess playing agent, and the other one incorporated a virtual representation with the same appearance on a computer screen. Then we performed an experiment to answer our research question, which was: *do people have more fun playing against the virtual or the physically embodied opponent?*

Similarly to Wainer's work (discussed in the related work section) and in contradiction to the eMuu study, this experiment showed that participants who had played against the physically embodied agent had higher enjoyment experiences than those who had played with the virtually embodied chess playing agent. We have supported Wainer's results and using the GameFlow model we were able to analyze each game element individually. This evaluation showed that the main reasons behind the difference of enjoyment in the two employed setups, was that the physical embodied agent had a more immersive user experience, an improved game feedback and a more believable social interaction. The dissimilar results presented in the related work may be explained by the fact that in those works different definitions of enjoyment were applied.

6. ACKNOWLEDGMENTS

This paper is supported by the EU projects MindRACES: from Reactive to Anticipatory Cognitive Embodied Systems (IST-511931) and LIREC: LIving with Robots and intEractive Companions (FP7-ICT-2007-1 with grant agreement no. 215554.), and by a scholarship (SFRH/BD/41585/2007) granted by the Fundação para a Ciência e Tecnologia.

7. REFERENCES

[1] Bartneck, C. 2003. Interacting with an embodied emotional character *In Proceedings of the 2003 international conference on Designing pleasurable products and interfaces*. Pittsburgh, PA, USA ACM Press.

[2] Bates, J. 1994. The Role of Emotion in Believable Agents. *Communications of the ACM*, 37(7), 122-125.

[3] Breemen, A. 2004. Animation Engine for Believable Interactive User-Interface Robots. *In IEEE/RSJ International Conference on Intelligent Robots and Systems.* Sendai, Japan, 2873-2878.

[4] Csikszentmihalyl, M. 1990. *Flow: The Psychology of Optimal Experience*. New York: Harper Perennial.

[5] DGT. DGT Projects. 2007 [cited 18/01/2007]; Available from: http://www.dgtprojects.com/

[6] Elliot, C., Lester, J., & Rickel, J. 1997. Integrating affective computing into animated tutoring agents. *In Proceedings of the IJCAI Workshop on Animated Interface Agents: Making Them Intelligent.* Nagoya, Japan.

[7] I.Poggi, C.Pelachaud, F.de Rosis, Carofiglio, V., & Carolis, B.D. 2005. GRETA. A Believable Embodied Conversational Agent. *In* Zancarano, O.S.a.M. *ed. Multimodal Intelligent Information Presentation.* Kluwer.

[8] Jegers, K. 2007. Pervasive game flow: understanding player enjoyment in pervasive gaming *Comput. Entertain.* , 5 (ACM Press), 1544-3574.

[9] Kanda, T., Hirano, T., & Daniel, E. 2004. Interactive Robots as Social Partners and Peer Tutors for Children: A Field Trial. *Human-Computer Interaction,* 19, 61-84.

[10] Kerrigan's, T. Tom Kerrigan's Home Page. 2007 [cited 18/01/2007]; Available from: http://home.comcast.net/~tckerrigan/.

[11] Leite, I. 2007. *iCat, the Chess Tutor*. MSc Thesis, Instituto Superior Técnico - Technical University of Lisbon.

[12] Leite, I., Martinho, C., Pereira, A., & Paiva, A. 2008. iCat: an Affective Game Buddy Based on Anticipatory Mechanisms. *In* Padgham, et al. *eds. 7th Int. Conf. on Autonomous Agents and Multiagent Systems (AAMAS 2008).* Portugal, Estoril.

[13] Lester, J.C., Stone, B.A., & Stelling, G.D. 1999. Lifelike pedagogical agents for mixed-initiative problem solving in constructivist learning environments. *User Modeling and User-Adapted Interaction,* 9(1), 44.

[14] Looije, R. 2006. *iCat for you: A comparison between different personal e-health assistants*. MSc Thesis.

[15] Marsella, S.C. 2003. Interactive Pedagogical Drama: Carmen's Bright IDEAS Assessed. *In Intelligent Virtual Agents.* 1-4.

[16] Martinho, C., & Paiva, A. 2006. Using Anticipation to Create Believable Behaviour. *AAAI 2006, Jul*, 175-180.

[17] Paiva, A., & Machado, I. 2002. Lifelong training with Vincent, a web-based pedagogical agent. *International journal of continuing engineering education and life-long learning,* 12, 254-266.

[18] Pfeifer, R., & Scheier., C. 1999. *Understanding Intelligence*. Cambridge, MA: MIT Press.

[19] Sweetser, P., & Wyeth, P. 2005. GameFlow: a model for evaluationg player enjoyment in games. *Comput. Entertain.,* 3(3), 3--3.

[20] Wainer, J., Feil-Seifer, D.J., Shell, D.A., & Mataric, M.J. 2006. The role of physical embodiment in human-robot interaction. *In IEEE Proceedings of the International Workshop on Robot and Human Interactive Communication.* Hatfield, United Kingdom, 117-122.