Just follow the suit! Trust in Human-Robot Interactions during Card Game Playing

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***Abstract*— Robots are currently being developed to enter our lives and interact with us in different tasks. For humans to be able to have a positive experience of interaction with such robots, they need to trust them to some degree. In this paper, we present the development and evaluation of a social robot that was created to play a card game with humans, playing the role of a partner and opponent. This type of activity is especially important, since our target group is elderly people - a population that often suffers from social isolation. Moreover, the card game scenario can lead to the development of interesting trust dynamics during the interaction, in which the human that partners with the robot needs to trust it in order to succeed and win the game. The design of the robot's behavior and game dynamics was inspired in previous user-centered design studies in which elderly people played the same game. Our evaluation results show that the levels of trust differ according to the previous knowledge that players have of their partners. Thus, humans seem to significantly increase their trust level towards a robot they already know, whilst maintaining the same level of trust in a human that they also previously knew. Henceforth, this paper shows that trust is a multifaceted construct that develops differently for humans and robots.**

I. INTRODUCTION

According to the World Population Prospects (`http://esa.un.org/unpd/wpp`), the United Nations envisions that the world population will dramatically age in the next few years. As such, the society needs to embrace this transition and develop ways to deal with it. Moreover, the elderly population commonly has physical or cognitive impairments, and current technology offers a possibility to deal and contribute to the Quality of Life (QoL), leading to successful aging[1]. In particular, assistive robots play a significant role in the technological evolution, as they could eventually be capable of providing elderly care.

However, QoL goes beyond meeting health care needs to address enjoyable and quality time, ultimately related with satisfaction towards ones life[2]. Therefore, when dealing with aged people with no serious health problems, that are still capable of doing their regular daily tasks, there is still a need to invest in their QoL, providing ways to occupy their free time with entertaining activities.

Our previous research [3] has explored the activities in which independent-living older adults require a robot. A panoply of different activities that they can still do by their own, but with some degree of difficulty, translates their need for assistance. Moreover, elderly people recurrently expressed problems related to social isolation and a need to reconnect. To meet this requirement, this paper presents the development and evaluation of a robotic game partner and opponent in a classical card game, which most elders enjoy playing. The main aim of this research was to develop an entertaining activity targeting the elderly population, using a social robot to help reconnecting people.

The card game scenario is an entertainment scenario in which three people play the game with a robot. This scenario is part of the PArCEIRO project[1], whose purpose is to study the role of social robotic players during tabletop card games with humans. The chosen card game was *Sueca*[2], since it is composed of two teams that simultaneously allow a partnership between two human players and between a human and a robotic player. This means our robotic game player can sustain two roles during the game: partner and opponent. This game in particular is one of the most played games among the elderly population in Portugal.

The Artificial Intelligence (AI) for some complex games has become very strong over the years. In fact, it has already defeated human world champions, e.g. Deep Blue, Chinook and Watson [4], [5], [6]. However, the increasing competence of these artificial players, may lead humans to generally consider them as fierce competitors. Yet, when we consider games played in social environments or when they require the AI to play as a social partner, people may still be wary of trusting AI to be up to human standards.

To analyze the performance of this scenario and how joyful participants felt, we conducted two user studies: one in a controlled lab environment, and another into-the-wild. We were interested in measuring the trust levels that participants felt towards the robot as a partner, and compared them to the trust felt towards human partners. Moreover, we analyzed the positive and negative affect after the study, and compared it with their baseline level. Finally, we studied the usability of our system and how expert *Sueca* players feel when they interact with it.

II. RELATED WORK

A. Elderly and Robots

Several projects have been investing in robotic technology to enhance QoL and successful aging, such as the ACCOM-

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[1]http://gaips.inesc-id.pt/parceiro

[2]https://en.wikipedia.org/wiki/Sueca_(card_game)

PANY project[3], CARE[4], ENRICHME[5], ExCITE[6], GiraffPlus[7], HOBBIT[8], RAMCIP[9], Robot-Era[10] and SILVER[11]. Moreover, Broekens et al. (2009), have reviewed robotic technologies in elderly care and have emphasized the positive effects of social assistive robots [7]. These kind of robots may vary from a service type to a companion type. The first ones are essentially focused on enhancing QoL aging of independently living elders. On the other hand, companion robots are also being used with therapeutic purposes.

In the service type, robots such as Pearl[8], Care-O-bot II[9], RoboCare[10] present many similarities regarding the guidance through environments and the management of elders' everyday activities. Their differences reside in their sensors and the interface of communication with the users. Overall, these robots were developed to provide home assistance for elders with an independent living or to complement caregivers' support.

In the companion type, the Paro robot was used in a one-year study with elderly participants possessing different levels of dementia and revealing increases on their moods and depression levels. Another example is the Huggable robot that was developed to accompany patients in hospitals. Both robots present extremely reactive functionalities regarding touch and voice inputs, and their primary goal is therapeutic.

Indeed, technology seems to be perceived as helpful for the elderly population, both for assistive purposes as well as for entertaining activities.

B. Entertainment Robots

Game playing scenarios are rich environments to develop human-robot interactions and the usage of social and emotional robots has been regarded as more entertaining and enjoyable when compared to virtual characters [11]. Leite et al. (2009), developed a robotic chess tutor for children and have analyzed how its social and empathic behaviors can improve children's engagement during the game [12]. Another social robotic game player is EMotive heaY systeM (EMYS) the Risk player that was used to improve social presence of an artificial opponent in the board game [13].

The role of robots in entertaining activities seems to have its importance, and more work needs to be developed to increase the usage of robots as a tool that re-connect people and provide joyful moments. In this paper, we developed an entertaining scenario in which elderly people and robots meet to play a classic card game.

C. Trust in Human-robot and Human-Human Relationships

According to Hanook et al. (2011), a human must trust a robot when interacting with it to have an effective usage of its capabilities, and to accomplish a common goal between them, in the case of a human-robot team. The authors conducted several experiments to examine which factors influence the trust measure in this type of relationship, and their studies revealed that trust in human-robot interaction is a constellation of three factors: human-related; robot-related and environmental. However, human-related factors (e.g. attentional capacity and personality traits) and environmental (e.g. task type and culture) presented a moderate effect on trust, whilst robot-based factors, especially performance-based, influenced the most trust towards a robot [14].

Thus, trust appears as a complex construct, especially linked to the robot's performance. However, trust in human-human relationships appears also as a complex construct with variables related to those of human-robot trust. Indeed, the actions of the other seem to contribute to the trust we deposit in one another. This is then related with the performance of the other, e.g., the type of decisions he/she performs, etc. Moreover, trust in human-human relationships is connected with the recognition of positive expectations for the other, despite of the inherent uncertainty. This includes cognitive, behavioral and affective states that we expect the other to have according to a given situation [15].

In this paper we have considered trust as a construct that informs us about the quality of the human-robot interaction in comparison with human-human interaction.

III. DESIGN

The goal of the aforementioned scenario was to create an autonomous robot that is able to play the *Sueca* card game on a touch table, and socially interact with its partner and its two opponents in context of the game. To achieve this goal, the design involved two different concerns: how can the social robot behave in a human fashion during the game (Section III-A); and how can the game interface handle the interaction between humans and a robot while respecting the usual game dynamics of *Sueca* (Section III-B).

A. Behavior Design for our Social Robot

According to Braezeal (2003), the robot's sociability increases with the ability to support a social model adapted to the environment [16]. As a result, we conducted a user-centered study to understand how human players behave during *Sueca* games, and to further include those behaviors in the design of our social robot.

The user-centered study took place in an Elder Care Center, where participants were told to play *Sueca* for as long as they wanted. The four male participants played 10 games during about 30 minutes and their performances were audio- and video-recorded for further behavioral analysis. Figure 1 illustrates participants setup during the user-centered study.

The behavioral analysis of the videos allowed us to obtain a list of game events that contains specific moments during a game where participants changed their previous behavior or interacted with other players. Moreover, we collected their verbal and non-verbal behaviors for each corresponding game event. We have also observed that the same game event

[3]http://accompanyproject.eu/
[4]http://care-project.net/welcome/
[5]http://www.enrichme.eu/wordpress/
[6]http://www.aal-europe.eu/projects/excite/
[7]http://giraffplus.eu/
[8]http://hobbit.acin.tuwien.ac.at/
[9]http://www.ramcip-project.eu/ramcip/
[10]http://www.robot-era.eu/robotera/
[11]http://www.silverpcp.eu/

Fig. 1: Elders playing *Sueca* during the user-centered study.

produces different behaviors according to who is doing it, i.e. self, a partner or an opponent. For instance, participants frequently used an encouraging tone when talking to their partners and a competitive tone to their opponents. The final list of our social robot's utterances was inspired by all the collected behaviors from the user-centered study and some examples can be seen in Table I. Additionally, the video[12] presented in [17] illustrates the social performance of our robotic game player, which was implemented on an EMYS robot.

TABLE I: Examples of utterances of the social robotic player.

Game Event	Utterance
Receiving own cards	<gaze(ownCards)> *Let's see...* <glance(dealer)>
Cutting the trick	<gaze(opponent1)> *Although I don't know where the ace is,* <glance(opponent2)> *I will cut* <glance(playingCard)> *this one!*
An opponent cuts the trick	<gaze(partner)> *What a bad luck... Look partner,* <glance(table)> *he cut it!* <glance(opponent)>

B. Entertainment Activity

In the previously mentioned user-centered study, we could also analyze the game flow of human players playing *Sueca* in the traditional scenario, and create the main usability requirements for the game interface of our scenario.

Sueca is a popular and traditional Portuguese card game among several age groups, including the elderly. Hence, its players are accustomed to a very specific game flow and speed, as well as the touch and feel of holding the cards. Furthermore, since it is a team game, some partners might even reach an intimacy level where they imperceptibly cheat through gestures, looks or moves, which confirms the engaging game experience some players are used to.

We have noticed participants attached great importance to their cards during the game. Firstly, they had to hold them in a way nobody else could see them. Secondly, their hands were at the locations they have most frequently looked at, which we attributed as a sign of deliberation about their next moves. As a result, our system had to use physical cards at the same time as it provides a mechanism for the robot to play and recognize the others plays. This usability requirement might be granted using a multimodal interface over a touch table that is capable of recognizing the cards, e.g. using fiducial markers on cards.

Considering this approach, we also analyzed the location that participants typically throw their cards over the table. The relevance of this question consisted in creating a mechanism to solve the possible overlap between cards. However, we have noticed that participants usually place their cards in the center of the table, although as near as possible to their location, so that other players can understand who has played each card. Additionally, if, after throwing a card, it overlapped another, participants have always adjusted the cards position, which eliminates the overlapping problem.

IV. System Architecture

In order to simplify the development and integration of our robot with the game, we use the SERA ecosystem[18], as shown in Figure 2. The Thalamus system provides the integration framework of all modules, Skene is the semi-autonomous behavior planner that uses a high-level language to manage the robot's behaviors, and Nutty Tracks is the robot's animation engine.

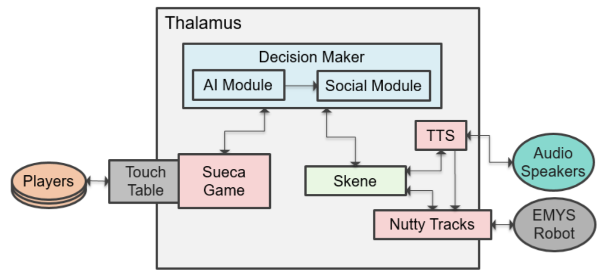


Fig. 2: The architecture of the *Sueca*-playing robot.

The Decision Maker Module represents our robotic agent in this system, and is divided into two modules, one for each of its main tasks, i.e. to compute the game and to prescribe social behaviors. Nonetheless, these two modules are regularly communicating with each other in a symbiotic manner to combine their outputs in a proper way. An example that illustrates this cooperational concept between the two modules is an opponent playing a card, which may trigger a behavior associated to the game event *opponent play*. At the same time, that play is computed in the current game state of the agent to calculate the benefit it produces for its team and that value can even be mentioned by the robot in a sentence and be used to update its emotional state. This emotional state is used in the Decision Maker Module and is produced by FAtiMA, the emotional agent architecture[19], in order to update the robots behaviors and posture.

When the AI Module has to choose a card to play, it uses the Perfect Information Monte-Carlo (PIMC) algorithm in its deliberation process. This algorithmic approach has obtained remarkable results in similar AIs for hidden information trick-taking card games, e.g. Bridge[20] and Skat[21].

The Sueca Game Module provides the interface, game engine and is also responsible for the physical cards recognition. Our deck had to be redesigned so that each card can include fiducial markers and, therefore, can be detected by the touch table[13] using the recTIVision framework[14], see Figure 3. The robots physical cards are recognized at

[12]https://vimeo.com/153148841

[13]https://www.multitaction.com/

[14]http://reactivision.sourceforge.net/

the beginning and then virtually played during the game. In this recognition phase, the cards are placed facedown, which justifies the need to include forwards a fiducial marker. Figure 4(a) illustrates the usage of the cards either by the robot and the human players.

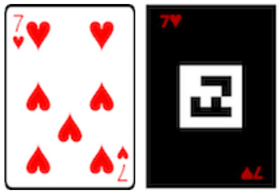


Fig. 3: Standard french deck card, on the left, and our redesigned card with a fiducial marker, on the right.

Nonetheless, the usage of physical cards also brought some limitations. Firstly, the differences between our version of cards and the traditional ones were pointed out as confusing and some players have sometimes played incorrectly due this misunderstanding. The purpose of the black background is to contrast with the white maker contour, and the more isolated the marker is, the better it will be recognized. The second limitation is the markers' recognition, which failed in 4 out of 100 games.

V. Studies

Two different studies were performed with the *Sueca* scenario: a *lab study* (see Section V-A) to analyze the trust levels of participants when partnering with a robot or a human during the card game; and an *into-the-wild study* (see Section V-B) in which we deployed our scenario in a *Sueca* tournament, providing an opportunity to test the game-play of this scenario with users that are expert *Sueca* players.

A. Lab study

This study was run in a lab and participants were adults who volunteered for the experiment. Although the target group for this scenario is elderly people, it is required to test the system before to understand how it is performing in a controlled lab setting. To do this, we conducted a lab study with the goal being to test if the scenario is stable enough. As *Sueca* is a partnership game, the aim goal of this study was to analyze the trust levels that humans feel towards their human or robotic game partners. As robots are a type of technology that usually triggers a novelty effect, we thus target the study of trust levels according to previous knowledge that participants had on their game partners (either humans and robot). This was possible, as some of the recruited participants participated in previous studies with the EMYS robot, and thus, had already interacted with it. In a similar way for the human-human partnership, some participants knew each other before playing the game, while others were strangers.

1) Procedures and Methodology: Each session involved three participants playing *Sueca* with the EMYS robot and lasted about one hour. At the beginning, participants' partners were selected in a draw so that one of them would be the robot's partner and the other two would be each other's partner. Before the game-play, they answered to a questionnaire to assess their affect (PANAS Questionnaire [22]), and the Human-Robot Trust Questionnaire [23] with an adapted version for participants with a human partners. The Human-Robot Trust Questionnaire measures trust in a scale ranging from 0% of trust to 100% of trust. We aimed to measure participants emotional state before the game, and also their trust expectation towards their partners. To have a standardized version of the game during the study one researcher explained the game rules and played *Sueca* with the three participants using the traditional french deck, before they started to play with the robot. Afterwards, participants were invited to play the game with the EMYS robot in a multitouch table, where the three participants played a session of five games with the robot (see Figure 4(a)). At the end of the five games, they answered to the post-questionnaires of PANAS, the Human-Robot Trust Questionnaire, and to some demographic questions. The goal was to compare the trust levels of participants towards the robot or the human partner according to their previous knowledge of the same partners, i.e., if it was a first interaction with them or if they already had interacted with each other.

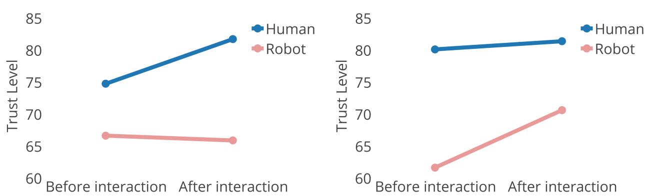
2) Sample: This study included 60 participants (M=24.31, SD=3.852; 20 females, 39 males, 1 unknown). 20 participants had EMYS as their game partner, while 40 had a human partner during the experiment. The majority of participants classified themselves with a medium level of proficiency in the *Sueca* game. We measured the robot's performance during the game to assure that the robot's ability to play did not interfere with the trust levels that participants felt towards it. Henceforth, its performance was measured according to the percentage of won and drawn sessions by its team. They won 12 sessions out 20 (60%) and drew 1 session (5%). This led us to conclude that the robot performed well during the game and showed a good playing ability.

3) Trust Level in the Game Partner: The trust levels were analyzed according to two factors: the partner type (human vs. robot); and the partner knowledge, i.e., the level of previous interaction with the assigned partner (in the demographics questionnaire this was controlled using the following statements: *"I have never seen my partner before"* vs. *"I have already interacted with my partner"*. We used a Mixed ANOVA statistical test to analyse if the aforementioned factors influenced the trust levels felt by the participants towards their partner. Results presented a significant difference between the trust levels before and after playing the game according to each possible partner type and partner knowledge ($F(1;49)$=7.093, sig=.010). Thus, when analyzing the participants that had no previous interaction with their partners before the game, we can see that those who partnered with a human seem to increase their levels of trust on their partner (74.50% to 81.47%) when compared to participants who partnered with the robot (66.38% to 65.64%) (see Figure 5. (a)). When analyzing the results for the participants that had already interacted with their game partner before, we can see the emergence of a different pattern. In fact, participants who partnered with a human

(a) (b)

Fig. 4: Participants playing the *Sueca* card game with the EMYS robot during (a) the lab study and (b) the *Sueca* tournament.

that they had already interacted with, showed equivalent level of trust on their partner (79.86% to 81.14%) (see Figure 5. (b)). Conversely, participants who had EMYS as their partner in the game and that had already interacted with it, show an increase on their trust level (from 61.39% to 70.37%). Moreover, the level of trust in human partners always appears to be higher than of the trust level in the robot.



(a) (b)

Fig. 5: Trust towards a human partner and a robotic partner according to the previous level of interaction with the partner, none in (a) and high in (b).

4) Affect: The PANAS Questionnaire specifies the emotional state into two dimensions: the positive affect and negative affect scales. We run a Mixed ANOVA statistical test on data and the results showed that the positive affect significantly increased when compared the affect before (M=29.77; SD=6.84; M=31.35; SD=8.11, for human and robot partners) and after (M=32.80; SD=7.75; M=33.15; SD=9.16, for human and robot partners) playing the game, F(1;58)=7.564, sig=.008, with no significant difference between conditions, F(1;58)=.488, sig=.488. These results shows that independently of having a robotic or a human partner in the game, participants felt with higher positive affect values after the interaction, revealing that the entertaining scenario triggers positive affect states in the players. When looking at the negative affect, results do not present significant differences before (M=11.48; SD=2.18; M=13.35; SD=4.25, for human and robot partners) and after playing the game (M=12.58; SD=2.98; M=13.25; SD=4.15, for human and robot partners), F(1;58)=1.257, sig=.267. Moreover, there was no significant difference for the negative affect before and after playing the game between different partner types F(1;58)=1.810, sig=.184. This shows that the negative affect did not increase after playing the game with the robot.

B. Into-the-wild study

This study was conducted during a *Sueca* tournament, where we aimed to examine different users interacting with the system, possibly including proficient *Sueca* players. For this experiment, the set-up was placed in a formal *Sueca* Tornament that occurs every year in a Lisbon area (see Figure 5. (b)).

1) Sample: The session lasted about 2 hours and the 15 subjects played 13 games with EMYS. Each group of three participants had played between one or three consecutive games. Then, participants and some members of the audience were asked to answer a questionnaire about their opinions related to the robot and the game experience using the multitouch table to play a classical card game. Thus, 15 participants and 2 members of the audience answered the questionnaire (M=22.62 years old, SD=10.73; 2 female, 14 male, 1 unknown).

2) Results: EMYS performance was evaluated using three multiple-choice questions:

- Question 1: “How well did EMYS play?”
- Question 2: “Which kind of mistakes did it commit?”
- Question 3: “Does EMYS play like a human player?”

Results show that EMYS’ plays were mainly classified as “It always played well” (70,6%), and participants reinforced this idea in the second question by mainly answering “It always played well” (75%). In the third question, the mode of the answers was “It is similar to a human player, although with some differences” (80%). Secondly, we tried to evaluate their perception of the game in terms of usability, considering it was a new experience playing a card game with physical cards over a multitouch table. The questionnaire also included two questions related with game dynamics using this type of technology:

- Question 4: “Did you like to play/watch the game over the touch table?”
- Question 5: “Which problems do think are relevant about this experience over the touch table?”

The majority of the participants answered that they “loved the experience” (64,7%). For question 5, although 25% found that “There were no problems”, the remaining answers were spread between “Sometimes the table takes too long to recognize the cards” (30%) and “The game flow is not natural” (35%). Interestingly, the *Sueca* champions did not want to play with EMYS. As this was a curious behavior, we talked to a few of them, and they answered they are *"not willing to lose their reputation by losing with a robot."*.

VI. Discussion and conclusion

In this paper we presented the development and evaluation of an entertainment scenario with a robot. The underlying motivation of this work was to meet (some of the) needs of the elderly population related with social isolation. This paper shows the design process of the scenario and the robot's behavior, as well as its evaluation in a controlled lab study and in a real-world context. As this scenario is about a card game in which people need to team up with their partners to beat their opponents, we measured the level of trust felt by participants towards their human/robot partner. We conclude that humans do trust a robot as a partner, but the trust level varies according to their previous knowledge of interaction with the same robot. Thus, participants that had already interacted with the EMYS robot, increased their level of trust after the game more than participants that had already interacted with human partners. However, participants without previous knowledge of their robotic partner did not increase their trust levels, suggesting that the development of trust towards robots may need longer interactions. These findings assist previous theories of trust, in which this concept appears as a complex construct. Indeed, trust in robots appears to be directly associated with performance, and since the robot had a good performance in terms of playing the game, humans trust it to be their partners. As for humans, trust between them seems to be linked not only with performance but also with expectations towards their behaviors, cognition and emotions, increasing the complexity of this concept. In line with this, trust between humans involves more than playing a game with them.

This scenario was also tested in the real world with the into-the-wild study, which suggested a successful performance of the social robotic autonomous partner in the *Sueca* card game for an uncontrolled environment.

Overall this study shows the success of implementing a social robot as a partner in a card game scenario, which is technically stable and reliable to be further tested with the elderly people. Therefore, our future work is to understand the impact this can have in their QoL.

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