It's Food Fight! Introducing the Chef's Hat Card Game for Affective-Aware HRI.

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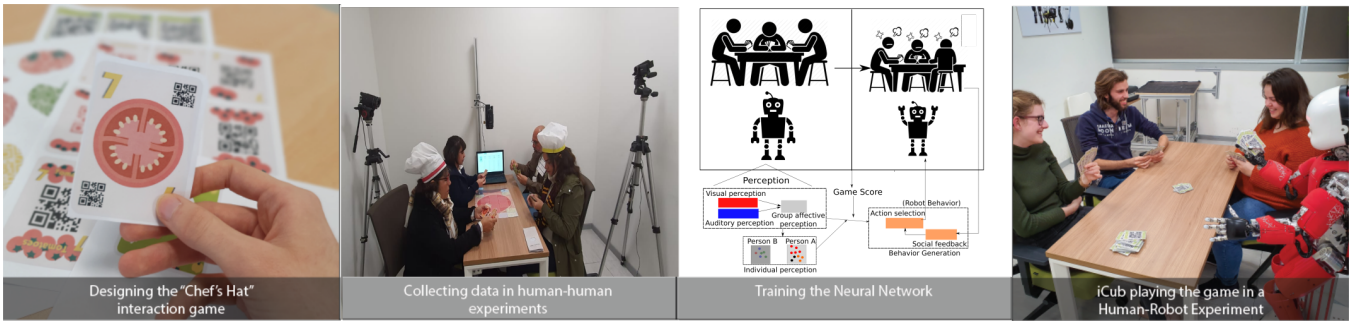

Figure 1: Our roadmap for an affective-aware HRI scenario: Developing the Chef's hat card game, collecting the behavioral measures during the game, designing learning models for autonomous robotics [3], and evaluating our scenario with real human-robot interaction.

ABSTRACT

Emotional changes during an interaction affect heavily how we perceive and behave towards other persons. To model an HRI scenario where the affective understanding can be observed and modeled properly, however, is still a very challenging task. In this paper, we continue our efforts in designing such a scenario, and to propose means of how it can be modeled by the means of artificial intelligence deployed in autonomous robots. Therefore, we describe here a novel HRI game scenario that was designed to address specific requirements that will allow us to develop the next wave of affective-aware social robots.

2020 Workshop Exploring Creative Content in Social Robotics, March 23–26, 2020, Cambridge, United Kingdom

KEYWORDS

Affective Computing, HRI, Card game

ACM Reference Format:
Pablo Barros, Alessandra Sciutti, Anne C. Bloem, Inge M. Hootsmans, Lena M. Opheij, Romain H.A. Toebosch, and Emilia Barakova. 2020. It's Food Fight! Introducing the Chef's Hat Card Game for Affective-Aware HRI.. In *2020 Workshop on Exploring Creative Content in Social Robotics at the ACM/IEEE International Conference on Human-Robot Interaction (HRI '20), March 23–26, 2020, Cambridge, United Kingdom.* ACM, New York, NY, USA, 4 pages.

1 INTRODUCTION

Associating perception and action in a long-term adaptation mechanism would improve how social robots interact and are accepted in real-world social scenarios [4]. Such architecture, usually approached by the means of cognitive computation, is the focus of several researchers over the past decade [5, 8]. In particular, modulating behavior based on affective perception has been explored and investigated by the affective computing community [6]. Most of the presented solutions, however, developed social interaction strategies based on emotion contagion [10] by repeating what was

perceived, or relying upon simple decision trees for generating behavior [9].

Such solutions are suited for the simple interaction scenarios in which they were deployed. The limitation on designing, implementing and deploying complex human-like scenarios, where affective information is indeed necessary is one of the problems that must be solved before the development of more complex affective modulation solutions.

In this paper, we continue our efforts (refer to our previous work [3]) on designing a social interaction scenario, based on a novel turn-based card game, to be used in affective-aware Human-Robot Interaction (HRI), also illustrated in Figure 1. The novel game, entitled The Chef's hat, was designed in an interactive process to guarantee that the display of affective behavior was natural and an integral part of the game mechanics. We also explore the social dynamics between the players as part of our game design. Also, the integration of robots into the game, as active players, is of fundamental importance. As such, we included elements in the games requirements and final mechanics that allow robots to understand the game status and the person's social behavior, and play without disturbing the game flow. As the game is designed to enforce teaming between the players, the occurrence of human-robot teaming behavior is an integral part of our game design decisions.

Our scenario provides a platform where different learning systems for affective perception, decision making, and behavior generation can be integrated, deployed and evaluated properly and in a close-to-real-world scenario.

2 THE CHEF'S HAT INTERACTION GAME

We have designed our novel card-game based on two principles: 1) to provide unrestricted and natural interaction, where affective behavior plays a significant role; 2) to provide a turn-taking environment, where the robot, represented here by the iCub [7], has enough structure to process incoming information and generate behavior without breaking the fluidity of the interaction.

2.1 Interaction Requirements and Initial Assessments

To maintain our two main principles, our card game was design to satisfy the following requirements:

- **R1** - The game should elicit a multitude of affective behavior that the robot can properly understand and model.
- **R2** - The game should be playable without the need of verbal expressions as part of the game mechanics to facilitate the affective understanding and processing.
- **R3** - The game should provide the possibility of creating strategies based on affective bonding between the players. This way, interacting with other players through the game's mechanics should be part of the game's natural flow.
- **R4** The game should have specific mechanics that, when used, cause affective reactions throughout the players.
- **R5** - The game should be easy to follow and to understand, having clear turns between the players. The number of actions to be made should be small and easy to process. This way, the limitations of the robot regarding decision-making, behavior display and processing time will be reduced.
- **R6** - The game status and players' behavior should be easy to track and monitor using automatic mechanisms (cameras and microphones). This way we can create a knowledge repository to leverage the learning of gaming strategies and behavior understanding by the robot.
- **R7** - The game should give players enough opportunity to interact with all other players through game-mechanics. Actions taken should not only affect the next player in the game, as this could limit both the social and the competitive strategies.

Game	R1	R2	R3	R4	R5	R6	R7
UNO	✓			✓	✓	✓	
Great Dalmutti	✓	✓	✓		✓	✓	✓
Quartet	✓		✓				✓
Skipbo		✓				✓	
Shithead		✓			✓	✓	

Table 1: Summary of which requirements are addressed by each of the tested games.

Taking these requirements into consideration, we started our design process by evaluating common card games that are well-known to persons from different cultural backgrounds: e.g. UNO, Great Dalmuti and Quartet. Each of these games addresses some of the requirements we listed above. Once these games were selected, we performed several rounds of experiments with four players playing each of these games.

We performed a behavioral observation to evaluate which requirements each of these games addressed. We recorded and analyzed all the players playing the game and the behavior observation was carried out by industrial design students, which were trained on evaluating and designing user interactions. Table 1 illustrates the results of such interactions.

Our analysis showed that very popular games, such as UNO and Great Dalmutti, fit most of our requirements, but not all. In particular, as discussed in our previous work [3], the possibility of causing adverse affective reactions throughout the gameplay was very present on UNO, but not in the others. On the other hand, the use of strong verbal component in UNO, and the lack of bonding throughout the entire gameplay made us perceive UNO as an incomplete game for our purposes.

Given that the Great Dalmuti game addressed almost all requirements, we decided to take it as inspiration for creating our own card game. It presents very simple game mechanics which are fairly easy to be understood and followed, similar to UNO, but without limiting strategic options as it is composed of different rounds with a continuing score. Furthermore, the hierarchy in the gameplay creates interesting group dynamics as well as opportunities for both competitive and social play.

2.2 Game Mechanics

Chef's hat is a card game in which players try to be the first to get rid of their ingredient cards and become the Chef. This happens for multiple rounds (or Shifts) until the first player to reach 15

points wins. Our game simulates a kitchen, and it has a role-based hierarchy: each player can either be a Chef, a Sous-Chef, a Waiter, or a Dishwasher. During every Shift there are three phases:

- Start of the Shift
- Making Pizzas
- End of the Shift

At the start of the Shift, the cards are dealt. Then, the Dishwasher has to give their two high-est values cards to the Chef, who in return gives two cards of their liking. The Waiter has to give their lowest-values card to the Sous-Chef, who in return gives one card of their liking. If a player has two Jokers at the start of the Shift, they can choose to play their special action: in case of the Dishwasher this is "Food Fight" (the hierarchy is inverted), in case of the other roles it is "Dinner is served" (there will be no card exchange during that the Shift).

Then, the making of the pizzas starts. The person who possesses a Golden 11 card may start making the first pizza of the Shift. A pizza is prepared when ingredient cards are played on the pizza base on the playing field. A pizza is done when no one can (or wants to) put on any ingredients anymore. The rarest cards have the lowest numbers. A player can play cards by laying down their ingredient cards on the pizza base. To play cards, they need to be rarer (i.e. lowest face values) than the previously played cards. The ingredients are played from highest to the lowest number, so from 11 to 1. Players can play multiple copies of an ingredient at once, but always have to play an equal or greater amount of copies than the previous player did. If a player cannot (or does not want) to play, they pass until the next pizza starts.

At the end of the Shift, the new roles are distributed among the players according to the order of finishing, and every player gets the number of points related to their role.

Several pilot data collections have been conducted and videos recorded and from the qualitative observation of these data the requirements indicated before have been met. We observed that the players exhibited clear emotional disruptions when the special actions were invoked. Also, we observed that some players developed group-based strategies against a player which had a higher score. Finally, the addition of the physical attributes was noted to give the players more motivations towards winning the game, which improved greatly their social engagement.

2.3 Game Elements

We started the design process of the “Chef’s Hat” card game taking Great Dalmutti as inspiration. In order to reduce the feeling of a controlled experiment and make the game feel more like a commercial card game, a theme was chosen and incorporated throughout all game elements. We opted for a Kitchen theme, where players compete to become the chef of a pizza restaurant. This theme has also been used to clarify and give reasoning to certain rules, as a means to make the game even more easy to follow.

Next to this, an important part of the design of the game elements was dictated by the game-state monitoring problem. The goal was to only have the need for one top-view camera to monitor the entire game-state.

The ingredient cards, illustrated in Figure 2, needed to be easily recognizable both when played on the playing field and when exchanged among players at the start of the Shift. For this, QR-codes were chosen, as they are hard for humans to recognize or memorize, but easy for computer vision to read.

Figure 2: Ingredient cards, and the Joker, with their corresponding face number. The lowest the number, the rarest the card.

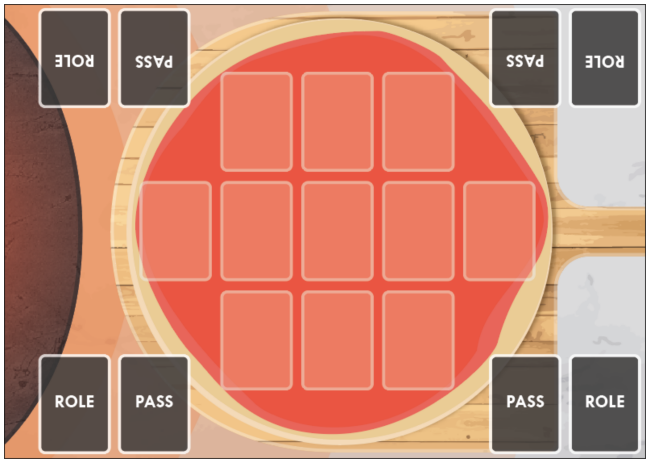

Figure 3: Playing field where the cards are placed, representing a pizza board.

The cards are to be placed on the playing field, illustrated in Figure 3. While testing the game, a recurrent problem was that players did not play their cards one by one (which made it difficult for the camera to pick up what was played). To counter this, it was opted to make a playing field with 11 different marked places in which players could place their cards on the pizza.

Role cards were made to make it easy to see which player has what role. The role cards have the additional functionality to work as a special action card when turned over. To increase engagement (and possibly competitiveness), it was opted to also have physical role-related attributes: a Chef’s hat, a Sous-Chef’s hat, a Waiter’s bow-tie, and a Dishwasher’s cloth. The attributes were color-coded per role (see figure 4).

3 NEXT STEPS: ROBOT LEARNING WORKFLOW

Our entire game was designed to be used in an HRI scenario, in particular to 1) evoke natural and clear emotional reactions and

Figure 4: Physical attributes used for each role: A - Chef, B - Sous-Chef, C - Waiter, D - Dish washer.

social dynamics in the participants; and 2) to enable a robot participating in the game to sense and monitor both the game status and the affective responses of each participant and of the group as a whole.

The goal for the robot involved in the game will be to understand the affective behavior of the human participants and use this informations, together with that of the game status, to select the best strategy to play the game. "Best strategy" in this sense will acquire different meanings. The robot might either aim at winning the game or at selecting the behavior the maximise a positive affective reaction in the other players.

One of the most challenging problems we will face is the mechanical interaction of the robot with the card game. We do not want to reduce the fluidity, or naturalness of the game from the player's perspective because this would destroy our general ideal of having a very natural scenario. The iCub is one of the most advanced social robots in the world, but still have limitations when interacting with real objects, in particular, with very thin objects such as cards. In this regard, we plan to adapt the way that the iCub interacts with the game. Our general idea is to have the iCub asking for help any time it needs to receive or withdraw a card, or put on and off a physical attribute at the beginning of the Shift and use the QR codes present in the card to generate an internal representation of which cards the robot has at hand. However, we are still evaluating the best way to make the robot place a card on the board during the game. Our current investigations involve weather by using a projector that will project the robot's card on the board or using a specific cardholder that the robot can point at when it wants to place a card.

To achieve the intelligent and adaptive behavior regarding the association between affective perception/display and game strategy learning, we envision a cognitive framework which will address the problem based on two perspectives: an adaptive affective perception, based on our previous work on artificial neural networks [1, 2], which will use an unsupervised affective memory mechanism to overcome the problems of online learning; And an interactive reinforcement learning strategy based on learning the social and contextual impact of a certain action by measuring the affective responses of the players, avoiding the necessity of active human interaction in the learning loop.

Such a system will be explored in more detail in our future work.

4 CONCLUSION

In this paper, we described our vision for an affective-aware Human-robot interaction scenario. In particular, we propose a new card game that encapsulates specific requirements which makes it suitable for playing with robots.

Our Chefs hat card game has specific elements that integrate continual affective understanding into the game mechanics. Also, it was designed in a way that learning mechanisms can be used to understand and produce affective behavior, and to learn game mechanics.

Our next steps will focus on the development of the learning mechanisms to realize an autonomous robot playing the game and on the exploration of how such a robot impacts the interaction within the players during the game.

5 ACKNOWLEDGEMENTS

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