Modelling Empathic Behaviour in a Robotic Game Companion for Children: an Ethnographic Study in Real-World Settings

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ABSTRACT

The idea of autonomous social robots capable of assisting us in our daily lives is becoming more real every day. However, there are still many open issues regarding the social capabilities that those robots should have in order to make daily interactions with humans more natural. For example, the role of affective interactions is still unclear. This paper presents an ethnographic study conducted in an elementary school where 40 children interacted with a social robot capable of recognising and responding empathically to some of the children's affective states. The findings suggest that the robot's empathic behaviour affected positively how children perceived the robot. However, the empathic behaviours should be selected carefully, under the risk of having the opposite effect. The target application scenario and the particular preferences of children seem to influence the "degree of empathy" that social robots should be endowed with.

Categories and Subject Descriptors

I.2 [**Artificial Intelligence**]: Robotics—*Commercial robots and applications*; H.5 [**Information Interfaces and Presentation**]: User Interfaces—*User-centered design*

General Terms

Human Factors, Experimentation

Keywords

Social Robots, Affect Recognition, Empathy, Children.

1. INTRODUCTION

Robots are becoming closer and closer to humans. Yet, for them to truly be part of our routines and daily lives, they must be able to interact with us, humans, in a similar way as we interact with each other [4]. Demographic trends, the decreasing costs in technology and the emergence of commercial robots for domestic settings are some of the reasons why research in this area is becoming progressively more relevant. There are still many open challenges when developing social robots for real-world environments. For example, the role of affective interactions is still unclear. As social beings, relationships are very important to humans. It is often argued that empathy, defined as "an affective response more appropriate to someone else's situation than to one's own" [15, p. 4], facilitates the creation and development of social relationships, increasing similarity, fondness and affiliation [1]. Would social robots also benefit from being empathic? In the field of HRI, there has been an increasing interest in studying different forms of empathy on user's attitudes towards robots [10, 23, 19]. However, most of these results were obtained in laboratory settings and the subjects were adults. When conducting studies with children, there are differences that should be carefully considered both in terms of methodology and data collection methods. For instance, with a few exceptions (e.g., [29]), most of the existing validated questionnaires are tailored for adults.

In this paper, we present a study that aims to understand how children perceive and interact with an empathic social robot in their school environment. To do so, we developed a robotic companion capable of recognising some of the children's affective states and react empathically to those states while playing a chess game. The presented study took place at a Portuguese elementary school where children interacted with one of the three versions of the robot: a neutral version, in which the empathic behaviours were not enabled, and two empathic versions that differed in the mechanism of selecting the robot's empathic behaviour. The results suggest that the empathic behaviours of the robot had a positive impact on children's perception of the robot.

The following section presents a state-of-the-art on HRI studies in real-world environments and empathic social robots. The scenario used for the study is then described. After that, we present the methodology used to collect and analyse the data, followed by the report of the most relevant findings of the study. Finally, we summarise the lessons learned and present some conclusions.

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2. RELATED WORK

Our goal is to qualitatively evaluate children's reactions to an empathic robot in a real-world environment. As such, this section presents a brief literature review in two distinct but interconnected areas: HRI studies in real-world settings, with special emphasis on examples reporting children's interaction with robots in schools, and studies involving social robots with empathic capabilities.

Recently, there has been a growing interest in studying the interaction with robots in real-world settings such as homes [12, 28], workplaces [22], elderly-care facilities [24] or schools. In this last category, Kanda et al. [16] reported an exploratory long-term study with elementary school Japanese children and a social robot (Robovie) capable of calling children by their names, adapting its behaviour to each child using a pseudo-development mechanism (the more a child interacts with the robot, the more different behaviours the robot displays to the child), and also self-disclosure behaviours. Robovie was capable of engaging children over the two-month period that the experiment lasted, although with a slight decay from the second week. The children's main motivation for interacting with the robot was to become friends with the robot. Kozima et al. [17] undertook a similar study to investigate the interaction between toddlers and Keepon, a small robot designed to interact with children through non-verbal behaviours. The authors report that children's understanding of the robot changed over time from a mere "moving thing" to a "social agent".

The first empathy studies in HRI focused on mimicking the user's affective state, a particular aspect of empathy also designated as emotional contagion. For instance, Hegel et al. [14] reported a study with an anthropomorphic robot that recognises the user's emotional state through speech intonation and then mirrors the inferred state using facial expressions. The results suggest that users who interacted with this version of the robot found the robot's responses adequate both in terms of appropriateness to the social situation and timing, comparing with subjects who interacted with the robot without affective expressions. In another emotional mimicry study [23], it was found that most participants considered the interaction more satisfactory than participants who interacted with a version of the robot without mimicking capabilities. More recently, Cramer et al. [10] studied how empathy affects people's attitudes towards robots. In this study, there was a significant negative effect on user's trust towards a robot that displayed inaccurate empathic behaviour. Conversely, participants who observed the robot displaying accurate empathic behaviours perceived their relationship with the robot as closer. A relevant finding in empathy research is that empathy is correlated with social supportive behaviours [15]. Saerbeck and colleagues [25] investigated the effects of social supportive behaviours of an iCat robot on children's learning performance and motivation. The results indicate that simple manipulations in the robot's supportiveness, while maintaining the same learning content, increased student's motivation and scores on a language test.

Although significant research has been undertaken in these areas, there are still numerous issues that require further investigation. With this paper, we intend to add another contribution in this field by analysing children's interactions with an empathic social robot in a school environment.

3. SCENARIO

The scenario that we developed to study empathy in social robotic companions consists of an iCat robot that plays chess with children and provides affective feedback to the moves played on an electronic chessboard. The robot interacts with children by displaying facial expressions and verbal utterances. The interaction starts with the iCat waking up and inviting the child to play (e.g., by saying "let's play chess"). After every child's move, the robot reacts emotionally to that move by displaying a facial expression [21]. Then, it asks the user to play its move by saying the move in chess coordinates. After that, the robot waits for the children's next move, and so on. The robot's behaviour is totally autonomous, except for an initial parametrisation where the name of the child needs to be typed in (the iCat uses the child's name in some of the utterances).

Previous user studies using this scenario have suggested the need of integrating empathic behaviours in the robot [18]. Taking this into account, we developed an empathic model that contains two main parts, an affect detection system that recognises the valence of the user's feeling and an action selection mechanism that chooses the best empathic response to display at a certain moment, for a particular user.

3.1 Affect Detection

The empathic model includes an affect detector that allows the robot to infer the valence of the feeling experienced by the children. The affect detector, based on Support Vector Machines (SVMs) [7], processes in real-time behavioural and contextual features, providing as output a probability value for each of the following valence conditions: positive, neutral and negative. The system was trained with features extracted from the Inter-ACT corpus, an affective multimodal video corpus containing previous interactions of a group of children with the iCat robot [6]. Previous work in this scenario showed that children's non verbal behaviour can be used to predict their affective state [26]. Specifically, the behavioural and contextual features used as input for the system are:

1. *Probability of smile* – the average value of the probability of the user's smile over the previous six seconds of the interaction; the smile detector uses Support Vector Machines and processes geometric features derived from 2D and 3D facial landmarks extracted using the Seeing Machines faceAPI sofware.
2. *Eye gaze* – the user's eye gaze is estimated based on position and rotation values of the head, relative to the camera, tracked by faceAPI; it provides information on the amount of time the user has looked at the robot in the previous six seconds of the interaction.
3. *Game state* – a quantitative measure that describes who is in a position of advantage in the game [5].
4. *Game evolution* – an indicator of how the game is evolving for each player [5].

3.2 Empathic Strategies

When the affect detection system recognises that the user is not experiencing a positive feeling with a high probability (taking into account the features described in the previous subsection), in addition to the affective facial expression, the robot employs an empathic strategy. The empathic strategies implemented in the robot, inspired in the literature of empathy and prosocial behaviour [9], are the following:

1. *Encouraging comments* – include comments such as "don't be sad, I believe you can still recover your disadvantage".
2. *Scaffolding* – providing feedback on the user's last move and, if the move is not good, let the user play again.
3. *Offering help* – suggesting a good move for the user to play in his or her next turn. If the user accepts the help, he/she touches one of the robot's paws and the iCat tells the move.
4. *Intentionally playing a bad move* – for example, playing a move that allows the user to capture a piece.

Each one of these strategies might have a different impact in different users. To address this issue, the action selection mechanism uses a reinforcement learning algorithm [2]. This way, the robot can adapt its empathic behaviour by trial and error considering the previous reactions of a particular user to an empathic strategy (for more details on the adaptive algorithm see [20]). Thus, we are investigating not only whether the introduction of empathic behaviours improves the interaction, but also if the adaptation of the robot's empathic behaviour over time plays an important role as well. To evaluate these two aspects, for this study we developed three different parametrisations regarding the robot's behaviour:

1. *neutral* – the robot does not exhibit any empathic strategies. It simply comments the moves in a neutral way (e.g., "you played well", "bad move", etc.).
2. *random_empathic* – when the user is experiencing a negative feeling, the iCat selects one of the enumerated empathic strategies randomly.
3. *adaptive_empathic* – when the user is experiencing a negative feeling, the empathic strategies are chosen using an adaptive learning algorithm.

In addition to differences in selecting the empathic strategies, the robot's affective feedback is also different in the neutral condition. As empathy involves putting oneself in the other's perspective [15], in the two empathic conditions the robot's affective behaviour is user-oriented (i.e., it gets happy if the user plays good moves and sad if the user plays bad), while in the neutral condition the iCat will be sad if the user plays good moves and the other way around. This will be reflected in the facial expressions displayed after every user's move.

4. METHODOLOGY

To analyse how children respond to the empathic behaviours implemented in the robot, we conducted a field experiment with three different control groups (neutral, random_empathic and adaptive_empathic), as described in the previous section. With this ethnographic study, not only we intend to capture children's reactions to the robot in a real setting, but also to identify patterns of responses and explore new ways in which we can improve the design of empathic robots.

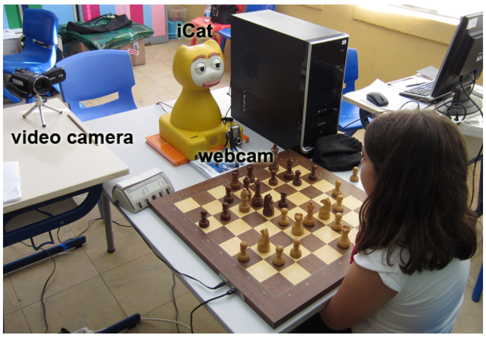

Figure 1: Setting of the Experiment.

4.1 Experimental Setting

The study was conducted in a Portuguese elementary school where children have two hours per week of chess lessons. As illustrated in Figure 1, the experimental setting comprises the robot, an electronic chessboard, a computer where all the processing takes place, a webcam and a video camera. The webcam was used by the face tracking software to capture the children's expressions that served as input to the affect detection system, while the video camera was used to record all the interactions. There was a third video camera recording the interactions from a lateral perspective that does not appear in Figure 1. The setting was installed in the room where children have their weekly chess lessons. The goal was to integrate the robot in the natural environment where children usually play chess.

4.2 Participants

A total of 40 participants (19 male and 21 female), with ages between 8 and 10 years old, took part in the study. Children from this age group are sufficiently developed to participate in semi-structured interviews and are able to answer questions with some consistency [3]. Participants were randomised over the three control conditions. Since we followed a between groups design, our final sample consisted of 14 children in the adaptive_empathic condition, 13 in the random_empathic and 13 in the neutral condition. As the number of subjects in each condition is not equal, when appropriate, we present the results using percentages rather than frequencies.

One week before the study, parental consent forms were delivered to the parents by the school's chess instructor. The consent from contained a brief description of the project and the goal of the experiment, including a note mentioning that the sessions would be video recorded for future analysis. All parents authorised their children to participate in the experiment.

4.3 Data Collection

Participants were guided to the room where the setting was installed and were instructed to sit in front of the robot. After the calibration phase for the face tracking system to work properly (which lasted no more than one minute), children played a chess exercise with the iCat. The exercise was the same for all participants, and was suggested by the chess instructor so that the difficulty was appropriate for the children. Two experimenters were in the room with the child controlling the experiment and observing the interaction.

Table 1: **Structure of the interview.**

Question	Response Type
1. Do you believe that iCat recognised how you felt during the game?	yes-no
1.1. Why do you think so?	open
2. Did you experience any particular emotions during the game?	yes-no
2.1. Which emotions?	open
2.2. Do you think the iCat felt similar emotions?	yes-no
2.3. Why?	open
3. Do you think the chess game is more fun because of the iCat (than playing with a computer)?	yes-no
3.1. Why?	open
4. What are the main differences of playing against the iCat compared to playing against your colleagues?	open
5. How could we further improve the iCat?	open
6. Identify advantages and disadvantages of playing with the iCat.	open

Each child played, on average, 15 minutes with the robot. After that period, depending on the state of the game, the iCat either gave up (if it was in disadvantage) or proposed a draw (if the child was loosing or if none of the players had advantage), arguing that it had to play with another user. During this phase, in addition to direct observation from the two experimenters in the room, two video cameras recorded the interaction from frontal and lateral perspectives.

After playing with the robot, participants were oriented to another room where they were interviewed by another experimenter. The interviews were semi-structured, containing initial yes-or-no questions followed by open-ended questions that allowed children to justify and elaborate their answers. The structure of the interview is depicted in Table 1. Each interview lasted on average 10 minutes. The interviews were audio recorded and later on transcribed. The interview transcriptions were used as primary sources of data for content analysis.

4.4 Data Analysis

The interview transcriptions were coded according to the methodology proposed by Chi [8], using an iterative coding process. An initial coding scheme was obtained while reading and highlighting the main concepts in the text. Subsequent iterations allowed us to refine the initial coding scheme. After that, related codes were grouped into themes and categories. To ensure reliability during the coding process, two complete coding iterations were performed with an interval of one month by the same coder. Differences between these two coding steps were addressed by asking another coder to rate that segment. Finally, using the developed coding scheme, a comparative analysis between the three different control conditions was performed to understand how the robot's empathic behaviour affected children's perception of the interaction.

5. RESULTS

The results presented in this section are divided by the main themes in the open-ended questions of the interview. In the first two themes (questions 1 and 2), our goal was to understand whether children perceived the empathic behaviours expressed by the robot and how such behaviours had an impact on children's own emotions. After that, we looked for the main differences between playing with the iCat and playing with a computer or a colleague (questions 3 and 4). Finally, children were asked about the advantages, disadvantages and ways of improving the robot, with the aim of gaining a better understanding on how, in the view of children, would be the ideal interaction with a social robot (questions 5 and 6).

5.1 Perceived Empathy

In the first question of the interview, our goal was to investigate whether children believed that the robot "perceived" how they were feeling during the game, and see if they refer to the implemented empathic behaviours to justify their answer. In other words, we wanted to see if they considered that the robot was being empathic towards them. As depicted in Figure 2, when asked whether they believed that the iCat knew how they were feeling, almost all the children from the adaptive_empathic condition and nearly 77% in the random_empathic answered "yes", while in the neutral condition only about 50% of the children provided an affirmative answer. The iCat's comments and helpful behaviour seemed to play an important role for children who answered "yes", especially in the empathic conditions, as these two participants stated:

> P18: *"I think so, because when I played bad moves the iCat warned me about that. He said what I was thinking."*
> P21: *"Yes, because for example when I played a bad move, he [the iCat] told me that I should do better [...] and when I didn't know what to play sometimes he told me that he could help"*

While in the empathic conditions most participants used the robot's behaviour and facial expressions to justify their affirmative answers, most of the participants from the neutral condition considered that the robot knew how they were feeling due to the cameras and because the robot was placed in front of them. For example:

> P34: *"Yes, because he saw my face and managed to memorise it"*

This effect might have happened due to the initial calibration phase of the face tracking software, in which children were asked to move their heads to different sides while looking at the robot. This procedure was done in all the conditions, even when the affect detection system was not being used, i.e., for children in the neutral condition.

As for the participants who answered "no", most of them were not able to justify their answer. In the neutral group, some participants argued that the iCat was too focused on its own game to have time to understand their emotions.

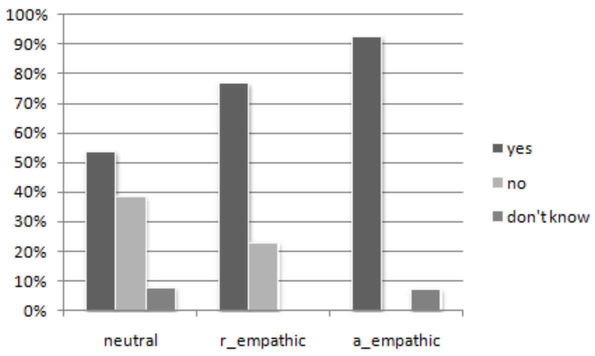

Figure 2: Children's answers to the question "Do you believe that the iCat recognised how you felt during the game?" in the three groups of users.

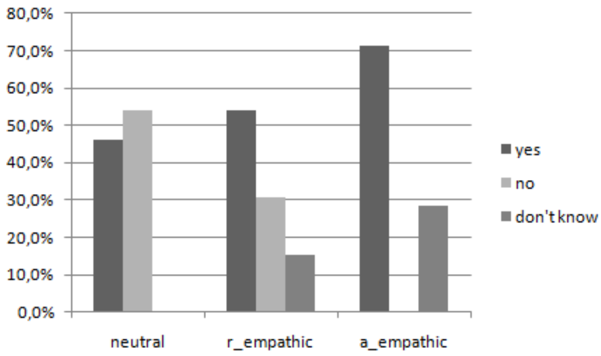

Figure 3: Children's answers to the question "Do you believe that the iCat felt emotions similar to the ones you felt?" in the three groups of users.

Table 2: Frequency of the reported affective and motivational states in the three conditions.

Category	neutral	r_empathic	a_empathic
happiness	3	1	7
nervous/anxious	1	3	0
enjoyed playing/fun	6	3	2
can't explain	1	2	2

Being a machine or a robot was another frequent reason given by participants who answered negatively:

> P25: *"No, because it's a robot and I don't think he feels the same things that people feel..."*

These results suggest that the implemented empathic behaviours influenced how children perceived the robot, as they frequently mentioned these behaviours to justify their affirmative answer. On the other hand, children who answered "no" often referred to the mechanical features of the robot. This leads us to believe that without the empathic behaviours, children perceive the robot more as a machine, and are less willing to suspend their disbelief during the interaction.

5.2 Experienced Emotions

The second group of questions was about children's experienced emotions while playing the game, and whether they believed that the iCat felt similar emotions. As in the previous group, we were looking for signs of perceived empathy: if children considered that the robot felt similar emotions, this would be an indicator of empathy. Most of the children in the three conditions answered affirmatively to the question "did you experience any particular emotions during the game?" (respectively, 77% in the neutral condition, 85% in the random_empathic and 79% in the adaptive_empathic condition). When asked about particular emotions, we obtained a variety of affective and other motivational states, which in the final coding phase were grouped into the categories presented in Table 2. Children who interacted with the adaptive_empathic version of the robot reported more frequently "happiness" as one of the experienced emotions:

> P33: *"I was happy! I have waited so long to play with the iCat but it was worth it."*

Other participants reported that they felt anxious or nervous during the game. From the observations of the interaction, we noticed that the experimental apparatus (children being alone in the room with the experimenters, the presence of the cameras, etc.) may also have influenced children to feel this way. For example, one participant from the random_empathic condition described his affective state as follows:

> P38: *"I felt weird... I was playing with someone I've never played before [...] I was a bit nervous..."*

In addition to the reported affective states, a significant part of the children also described other positive states and reactions when asked about emotions, which can be explained by the fact that children's understanding of emotions is still under development at this age. As argued by Denham and colleagues [11], some children are more skilled than others in experiencing and using emotional vocabulary due to several factors such as gender, parent's emotional displays of affection and children's own past experience. Therefore, they used terms such as "enjoyed playing" or "I felt that I was having fun" to describe their emotional experience. Others even highlighted the fact that they were playing with a new robotic product, which is still not available to everyone. When asked about the emotions experienced during the game, one participant from the neutral condition answered:

> P34: *"I felt a big honour for playing with a robot that is not for sale yet!"*

As illustrated in Figure 3, more participants from the two empathic conditions considered that the iCat felt similar emotions to the ones they have reported, whereas in the neutral group this effect was not so substantial. Moreover, the affirmative answers in the neutral condition seem to be biased by an effect that we were unable to control: as children were very curious and expectant about the presence of the robot, the ones who played first spoke about their experience to the others. We noticed this because some of the children, at the end of the game, asked us questions such as "one of my colleagues told me that the iCat suggested him a good move... why didn't he do that with me?". Also, some children who played with the neutral version of the robot reported behaviours that do not happen in that condition (for example, the robot offering help). One of the participants even said that directly:

> P22: *"Yes, because I was told that he can do that."*

In sum, nearly all the children experienced emotions while playing chess with the iCat. However, the type of reported emotions changed slightly among conditions: while happiness appears in almost all the descriptions of children in the adaptive_empathic condition, children in the neutral and random_empathic conditions reported less positive emotions. An interesting finding was that negative affective states (e.g., anxious, nervous, etc.) were mentioned more often in the random_empathic condition, which may indicate that the introduction of empathic behaviours should be done carefully under the risk of confusing the users.

5.3 Comparing Robots with Computers

To gain a better understanding of how children perceive social robots and how the presence of the robot might influence their opinion of the chess game, we asked them what did they consider more fun, playing against the iCat or playing against a computer. All the participants except one (P18) agreed that playing the game against the iCat was more fun. The only participant who did not answered this way gave the following answer:

> P18: "For me it's the same, playing chess is always fun. But I had a lot of fun playing against the iCat".

As for the reasons why playing with the iCat was more fun than playing with a computer, there were some differences in the answers provided by participants from the different conditions. In both empathic conditions, children often referred to the helping behaviours of the robot as the main difference between playing with the robot when compared to playing with the computer. Also, some participants mentioned that playing with the iCat is more similar to playing with another person:

> P10: *"because the iCat is like a person but it's a robot."*
> P16: *"because he [the iCat] can say if I played well or bad, what he thinks about our moves... and also because we can talk to him."*
> P24: *"[the iCat] has emotions, and computers don't. He speaks and actually is a good friend and player."*

There were some aspects that were evenly used by participants in the three conditions. For example, the fact that they never played with a robot before, they need to play the iCat's moves while the computer plays automatically, the robot speaks, and also the robot's emotional and facial expressions.

5.4 Comparing Robots with Humans

After asking about the differences between robots and computers, we asked children what were the main differences between playing with the iCat or playing with their colleagues. There were differences between the answers provided by subjects from the adaptive_empathic condition and the two other conditions. Most children from the adaptive_empathic condition indicated as the main difference the fact that the iCat provides help and comments, or simply that playing with the robot it more fun than playing with their colleagues (for example, because the iCat allows them to take back moves). Conversely, many participants from the neutral and random_empathic conditions mentioned embodiment aspects of the robot as the main difference, and compared the robot's skills to the skills of a computer:

> P16: *"the iCat doesn't have arms and we need to play his moves, and I need to say yes when he proposes a draw. I need to play really well to beat him."*
> P38: *"the main difference is that [the iCat] is a robot, and my colleagues are regular people like me. Also we don't think the same way [...] the iCat thinks the way computers think."*

The expressivity and emotional behaviour of the robot was also frequently mentioned as one of the main differences, especially by participants from both empathic conditions:

> P26: *"[my colleagues] are not so fun, they don't smile when they are winning and don't get sad when they are loosing... I've never seen their feelings, but at least their faces... they never get very sad."*
> P17: *"[my colleagues] don't get so excited, they don't show so many emotions... and the iCat gives us advice, and people don't."*

Some children also highlighted the fact that the iCat is more focused in the game than their colleagues but, at the same time, does not try to rush the game:

> P33: *"my colleagues often say 'come on, play!' while I'm still thinking... and the iCat doesn't, he waits for my move, lets me think..."*
> P35: *"the iCat is very calm, he is always there focused in the game. [my colleagues] are always looking at something else and I am waiting, looking at the [chess] clock."*

5.5 Advantages, Disadvantages and Suggestions

The last part of the interview contained questions in which children were encouraged to provide suggestions on how we could improve the robot, and indicate advantages and disadvantages of the interaction. The answers to the question "how can we further improve the iCat?" were coded into 4 different groups: suggestions regarding embodiment, behaviour and chess skills of the robot, and another category for the ones who considered that there is no need for improvement or were unable to name any suggestion. The category regarding embodiment included suggestions such as "the iCat should make less noise", "the robot should speak more slowly" or references to the addition of arms and other body parts, so that it could play its own moves. These suggestions regarding embodiment were more frequent in participants from the neutral condition. On the other hand, children from both empathic conditions provided more suggestions related to the chess skills of the robot. For example, some participants stated that to improve the iCat it should play chess more often, others that it should play an entire chess game instead of playing a chess exercise. As for the suggestions regarding the behaviour of the robot, while participants from the neutral condition proposed that the robot should be more helpful (or provide help when asked), children from the empathic conditions suggested improvements related to the expressivity and affective behaviour of the robot, for example:

> P34: *"he is joyful, and we get happy... it's like playing with real cats... it's very funny because he smiles and gets very emotional about our moves".*
> P33: "you could include a system for the iCat to say what he really feels about the moves I've done. I wouldn't be upset if sometimes the iCat say what he really feels..."

This last statement suggests that, even though the empathic behaviours of the robot improve the interaction in may ways, some users interpret these behaviours as less natural when compared to the behaviour of their chess mates. This result reinforces the idea that the robot should adapt its behaviour to the preferences of the child.

In terms of the advantages of playing with the robot, we did not found substantial differences in the advantages enumerated by children among the three conditions of the study, except for the fact that some children from the empathic conditions referred to the helping behaviour of the robot as one of the advantages. The most referred advantage indicated by the participants was that the iCat is a novel experience, as none of them had played with a robot before:

> P16: *"he is more funny because it's a robot, and we don't see that everyday."*
> P19: *"it is a novel experience, the iCat is a robot and I've never played with a robot before."*

Children also highlighted that they learn more when playing with the iCat due to the robot's comments during the game (when compared to playing with their colleagues or playing chess in the computer). Also, they considered that playing with the robot is more fun, which can be explained by the novelty effect of interacting with a social robot.

The majority of the participants said that there were no disadvantages or were unable to list any disadvantage. Only 6 children indicated disadvantages, 3 from the neutral condition, 1 from the random_empathic and 2 from the adaptive_empathic. Some children considered that playing the robot's moves is a disadvantage. However, others referred that as a positive aspect in earlier phases of the interview. Also, some children said that the robot speaks too fast, for example:

> P39: *"the disadvantage is that he is a robot, and does not have arms or legs. Legs aren't a problem, but the arms... sometimes I didn't understand what he said, it was a bit difficult to understand."*

We believe that the novelty associated with the interaction with a social robot contributed to the low number of disadvantages indicated by children. Also, we noticed that most children were not very comfortable in talking about disadvantages to the interviewer, which they considered one of the "builders" of the robot.

6. LESSONS LEARNED

The findings presented in the previous section reinforce the idea that empathy is an important mechanism so that social robots can interact naturally with people. Overall, children enjoyed the interaction and often mentioned the empathic behaviours of the robot as positive aspects. However, if not chosen appropriately, the robot's empathic behaviours might have a negative effect: while most of the children interacting with the adaptive_empathic version of the robot reported happiness as the most prominent emotion during the game, children who interacted with the random_empathic version of the robot reported more negative emotions such as "anxious" or "nervous". Also, some children felt that the robot was too nice for them, saying that they would not mind if the robot showed its "real feelings". These observations are important for deciding the "degree of empathy" in a social robot in two ways. First, the empathic behaviours (and the number of times they are employed) should be suitable to the application scenario where the robot is immersed. Second, as this might be a decision that depends a lot on the particular presences of users, the robot should be able to learn the best strategies for keeping that user in a positive affective state.

We also found that the amount of speech and comments of the robot seem to be appropriate for this type of scenario. None of the children seemed to notice that the robot does not have speech recognition capabilities, nor did they expressed any desire to interact with a more talkative robot. These results suggest that the perceptions of the game and the affective states of children are enough for generating believable verbal behaviour in social robots that act as game companions for children.

Our study also revealed some important lessons concerning the design of HRI studies with children. Collecting valuable data from 8 to 10-years-old children can be a challenging task. For example, some children were shy for being alone with the interviewer and provided short answers to the questions, or said that they did not know the answer. To address this issue, we suggest group interviews rather than individual interviews, since children tend to become less shy when they are in the presence of other children. At this age, some children still lack emotional vocabulary, or do not have a concrete idea of what an emotion is. Concerning this issue, we suggest the use of more visual methods to encourage children to talk about emotions (for example, by using a simplified version of the Geneva Emotion Wheel [27]).

Another observed effect was children's intrinsic tendency to please adults, also pointed out by Hanna and colleagues [13]. We noticed that very few participants were capable of enumerating disadvantages of the robot, but most of them provided many suggestions when asked about improvements for the iCat. As children are usually not very comfortable in discussing the negative aspects with adults (especially when they think that the adult owns the target of discussion), the interview should include constructive questions such as "how can we improve...", rather than directly asking for disadvantages.

7. CONCLUSIONS

In this paper, we presented a first evaluation of an autonomous social robot capable of performing an "affective loop", that is, recognising some of the user's affective states and displaying appropriate empathic behaviour. The study was conducted in a school setting, more precisely in the room where children usually have their chess lessons. The empathic behaviour of the robot was well understood by children, as they used it frequently to justify their answers to the empathy related questions in the interviews. The obtained results are in line with previous empathy studies with adults, in the sense that empathy facilitates the interaction and affects positively the perception of the robot. The findings also suggest that the selection of the empathic behaviours should be done carefully, under the risk of having the opposite effect. A similar result was discovered by Cramer et al. [10], where the presence of inaccurate empathic behaviours had a negative effect on adults' trust towards the robot.

Although more empirical work is necessary to validate the findings presented here, this study is an important contribution for the iterative process of designing an empathic robotic companion for children. Further research is also needed to verify if the results can be extrapolated for designing empathic social robots in different application domains and for other target users such as the elderly.

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