

Towards Companion Robots Behaving with Style

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Abstract—Sociability of companion robots is one of the challenges that the field of human-robot interaction faces. Inspired from research in psychology and sociology dealing with inter-personal relationships, we aim to render robots capable of a behaviour compatible to be among humans. In the context of a companion robot for children, we propose different parenting styles (namely authoritative and permissive) and evaluate their effectiveness and acceptability by parents. We implemented behaviours of different styles played out by two robots, Nao and Reeti, with body and facial channels respectively for communication. 94 parents watched videos of the robots and replied to a questionnaire about the authoritativeness, effectiveness and acceptability of the robots. The results showed that robots can be perceived as dominant and authoritative; however their effectiveness as an authoritative figure is limited to young children and is correlated to the style played when giving an order. When given a choice between authoritative and permissive styles, the parents ended up not always choosing a parenting style similar to their own. This work contributes in formalising context dependent personalisation to parent expectation of a companion robot for children using the concept of styles.

I. INTRODUCTION

Social robot companions need to dynamically adapt to their context of use : changes in the environment, in the embodiment or of the user's expectations. As the word companion suggests, the robot is expected to create engagement and try to build a long term relationship with the concerned user. Interaction between children and their virtual companions should be multi-layered. According to the context, the companions should be able to play several roles depending on the situation - it can be a buddy, a coach, a teacher etc [1].

However the community working on companion robots is facing low acceptability of these devices in home-environments. Besides, when talking about a companion for children, we can imagine that some kind of control of the situation should be shown by the said device in order for it to be better accepted and trusted by the parents.

All of these problems are aimed to be solved by increasing social competences of the companions. This passes by using social signals such as emotions, moods and attitudes.

[2] expands on research in technology design for children considering parents' opinions. Our research takes parents' acceptability of the virtual companion as a challenge. At early ages, children see their parents making decisions about the commodities that the children pass most of their time

with. The parents should find a certain *worth* [3] in having a virtual companion for their child.

Research in Human-machine interaction has shown that usage varies not only according to the user (from one individual to another), but also on the environment. This work presents a way to personalise robot's behaviour in a particular context that requires the companion to show control of the situation. Our goal is to show that parenting styles can be a way to affectively modulate the behaviour of a companion according to the user. Style is a psychological concept that corresponds to the mannerism used to play a particular role. This notion is therefore context dependent. Authoritative and Permissive parenting styles were expressed by Nao[4] and Reeti[5] robots.

Evaluation of perception of these expressions through videos showed to parents displayed individual differences in acceptability and effectiveness for both styles. However, we determined that there was no correlation between the users' parenting styles and the one they picked for the companion robot of their child.

II. PROBLEM & CHALLENGES

In the work "Theory of companions" [6], the author recommends to work on sociability of companion robots - "Getting people to engage with companions is easy but keeping them engaged is a hard task." Even more than in design of other technologies, design of sociable entities must adapt to inter-individual differences. As presented in Worth Centered Design [7], [3], adaptation of technology to the user and to its context of use is crucial. For companion robots, this is instantiated by the importance of role taking and the mannerism of playing these roles. Our work aims to contribute on both questions of personalisation and context adaptation of companion robots by empowering the notion of styles in role playing.

III. RELATED WORK

A robot companion coaching a child and managing his schedule could use different way of asking a conative effort to the child. Our scenario takes place when the child is playing when its companion asks him to start to do his homework. In order to formalize these different ways of playing the social role, we are interested in the notion of *styles*.

A. Styles In Psychology

Since many years, industrial projects have been using tests based on styles to improve collaboration in team tasks. Teachers have also been adapting their methods and styles to suit different learning styles of students [8], [9]. *Style* is a

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notion in psychology that describes categories of behaviours displayed by people with specific roles. Hence there are different types of styles corresponding to each social role. There are learning styles observed among students or apprentices. Similarly, teaching, managing, parenting also have their associated styles. These styles are used to categorise people and their behaviour in different situations [9]. We clearly see the link of the style with the social context.

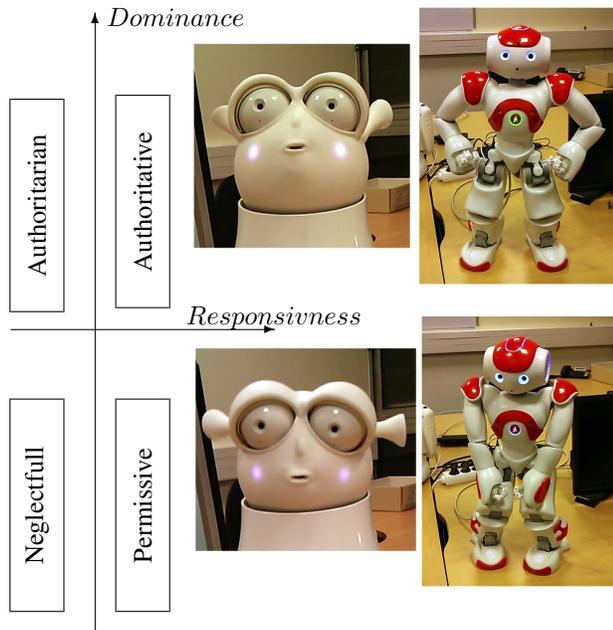


Fig. 1. 4 Parenting Styles arranged in the 2 dimensions, dominance and responsiveness with the illustration of the 2 robots (Reeti on the left, Nao on the right), expressing the 2 styles with higher responsiveness

A formal typology of parenting styles was introduced by Baumrind in the 70's. Since then, several studies have approved the robustness of this typology and proposed ways to measure them [10]. Originally; only 3 types of parenting styles were proposed by Baumrind. The fourth type, *Neglectful*, was added by Maccoby and Martin in the 80's. The figure 1 arranged the four types in a 2 dimensions corresponding to the level of dominance and responsiveness. The scale of *dominance* would evaluate the degree of demanding behaviour, discipline and punishment used by the parents. The second dimension, *responsiveness*, refers to love, warmth and attention that is given to the child.

Since the context of this work is based on a robot companion for children, we consider that it is mandatory for the companion to be sensitive and responsive to the children and parent user. Therefore, we evaluate only the two styles with high responsiveness : Authoritative and Permissive styles.

Expression by robots of personality and complex emotions are often hard to reach due to their motors' limitations. To compensate and check which modalities were important to depict parenting styles, both facial and body should be tested.

IV. EXPERIMENT

The conducted experiment aimed to evaluate expressibility of parenting styles by companion robots. We also wanted to evaluate the effectiveness and the acceptability of the styles with the help of parents. There could possibly be a consensus in the context where all parents would want an authoritative companion. We could also find a correlation between the style they have as parents and their choice of style for the companion of their children.

A. Hypothesis

In order to pursue our work on personalisation and adaptive design of social robot companions, we built an experiment to verify several experimental hypothesis. These hypothesis are listed below.

H1 Authoritativeness is expressible by robots using non verbal communication channels.

H1a Parents perceive a difference in authoritativeness between both Permissive and Authoritative styles when expressed by a robot (the robot Reeti, in our case) with facial and voice based social cues.

H1a Parents perceive a difference in authoritativeness between both style Permissive and Authoritative when expressed by a robot (the robot Nao, in our case) with body and voice based social cues.

H2 The perceived effectiveness of an authoritative robot is higher than a robot with permissive style in the context of giving a direction.

H3 In the particular context of giving an order, there is a significant inter-personal variability of preferred parenting style for the robots.

H4 The variability of acceptability of the style expressed by the robot is correlated to the own style of the user.

B. Protocol

93 parents participated in the experiment (63 women and 30 men). We used two robots, a robotic head Reeti [5] and the humanoid robot Nao [4]. Each participant watched two videos of the each of the two robots expressing respectively the two parenting styles: Permissive and Authoritative. They were then asked to reply to a questionnaire.

Nao is a small humanoid robot that was used to explore the body channel of non-verbal communication of the styles. We used postural openness, arm gestures, facing orientation as well as paralinguistic cues such as voice volume, pitch and speed of the speech (further details in the next section).

The expressibility of Reeti relies on its facial expression. Reeti is able to express simple emotions using facial channel of communication as well as its ears and paralinguistic parameters to modulate its voice.

C. Multi-modal expression of Permissive and Authoritative parenting styles

In order to depict the styles using multi-modal non-verbal and paralinguistic channels of communication, we used modalities of expression of verticality specified by Hall and al. [11]. Hall describes a set of non-verbal cues

said for *verticality* that we used to express dominance and submission to differentiate between Authoritative and Permissive style of parenting (cf Figure 1). We have adapted the categories of non-verbal behaviours according to the physical constraints of each robot.

In order to modulate the behaviour of each style, we used some parameters from the literature [12], [13], [14], [15], [16]. We used spatial variables such as space occupation, direction and amplitude of gestures. Other parameters were employed for the dynamics: repetition, speed of gestures, speed of decay and fluidity/rigidity of movements.

In the paper [11], Hall describes a list of non-verbal categories of behaviours that can be used to depict *verticality*. In this paper, we associated the verticality to our dominance allowing us to use these cues to build behaviour with high or low dominance. As mentioned, the physical constraints of the robots differed in the fact that one (Nao) was using body language and the other one (Reeti) using facial expressions. We also referred to the work of Breazeal [17] for the ear movement of Reeti. Nao and Reeti both have possibilities to change the colour of their LEDs. Colours have been proved to be useful to display emotions. However, as presented in [18], colours are attached to the Pleasantness and Arousal dimensions of emotion. Since only Dominance is an emotional dimension that is important to discriminate parenting styles, we avoid the use of colours variation to express the style difference.

After the analysis of concerning literature, we built the table I showing the positive (\nearrow) or negative (\searrow) influence of each behavior on the dominance for each robots. For example, for both robots, a high blinking rate decreases the dominance factor, inversely voice loudness will increase with dominance.

Modality	Nao	Reeti
Gaze	\nearrow (intensity of eye light)	\nearrow
Blinking rate	\searrow	\searrow
Nodding	\searrow	\searrow
Self contact (hands or face)	\searrow	\searrow
Self contact (hips)	\nearrow	
Hand and Arms: illustrator, emblems	\nearrow	
Postural openness	\nearrow	
Postural relaxation	\nearrow	
Face orientation	\nearrow	
Voice Loudness	\nearrow	\nearrow
Voice Pausing	\nearrow	\searrow
Voice Pitch		\searrow
Voice Speed	\nearrow	\searrow
Ears		\searrow

TABLE I

SUB-LIST OF CATEGORIES OF BEHAVIOURS [11], [17] USED TO DISPLAY THE STYLES

D. Questionnaire on perception, acceptability and effectiveness of the robots

The questionnaire based on [19], [20], [10] was associated to the videos. Each participant saw one robot acting with both permissive or authoritative style in a randomized balanced order.

The first part of the questionnaire was dealing with context of use and usage of new technologies. This part aimed to detect signs of technophobia that could have biased our study. As presented in [21], some negative attitude toward robots could lead to anxiety and rejection. In the other hand, technophilia and past positive experience with robotic devices can facilitate their adoption[22].

Permissive and authoritative style are distinctive by their level of dominance. In order to be sure that this difference was perceived in the behavior of the robots, we asked the users to evaluate the emotional mental state of the robot. We used the PAD scale from [23] with the SAM representation [24]. We asked them to rate each of the two styles they saw according to the pleasantness (P), the arousal (A) and the dominance (D) from 1 to 5. This dominance measure helped us to detect if the participant thought that the robot was in control of the situation.

We also asked the users about their opinion on the effectiveness of the robots in giving an instruction. This aimed to evaluate the perceived competence of the robot in this particular context. Bartneck in [25] categorized this dimension in the perceived intelligence of the robot.

In the last part of the questionnaire, we used items of a questionnaire on authoritative in parenting style from [10] to evaluate the user's behaviour with his children. The Parental Authority Questionnaire Revised (PAQ-R) proposed by [10] is a 30 statement 5-scale Likert questionnaire. We extracted questions regarding authoritative and permissive parenting styles only (20 questions). in order to minimize the length of the questionnaire, so that the participants do not loose interest while responding.

V. RESULTS & DISCUSSIONS

A. Perception of Authoritativeness and Dominance

Results from the emotional state evaluation showed that the emotional state was mainly influenced by the dominance dimension.

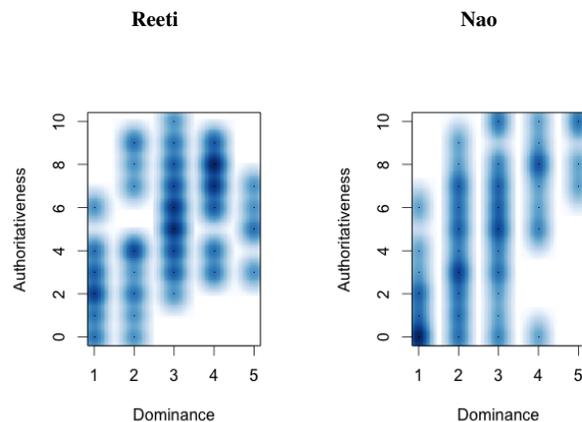


TABLE II

SCATTER PLOT SHOWING THE CORRELATION BETWEEN PERCEIVED DOMINANCE AND AUTHORITATIVENESS

We conducted a Pearson correlation test on the Dominance and Authoritativeness variables. The correlations between these variables are illustrated on table II. For both robots, the Pearson correlation test showed high positive correlation between Dominance and Authoritativeness (Reeti: $R^2 = 0.5447773$, Nao : $R^2 = 0.6680873$).

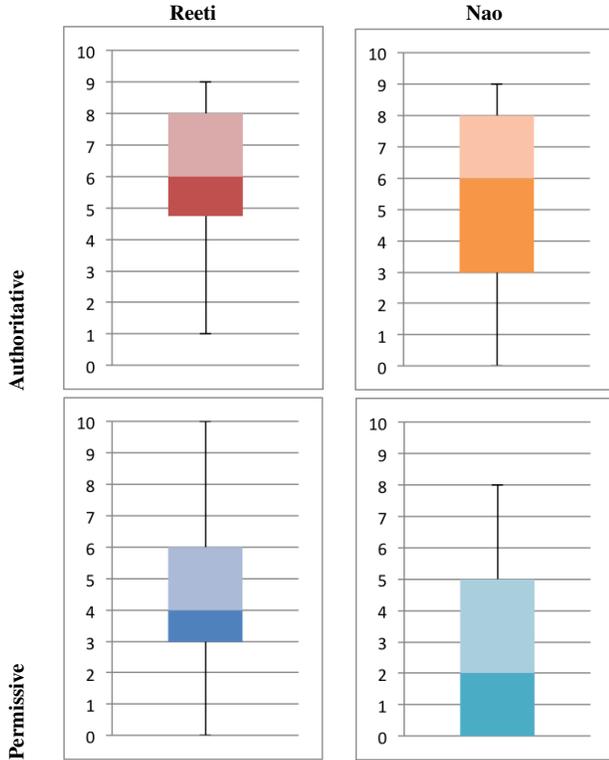


TABLE III

BOXPLOTS OF PERCEIVED AUTHORITATIVENESS (ON A 0 TO 10 SCALE) OF NAO AND REETI ROBOTS EXPRESSING AUTHORITATIVE AND PERMISSIVE PARENTING STYLES

Parents were asked to grade the behavior in terms of authoritativeness: "How authoritative is the robot from 0 to 10 ? (0 not authoritative at all, 10 very authoritative)". The table III presents box plots of perceived authoritativeness of the robots in the four modalities tested.

The behaviors displayed by the robot Reeti seems to create more of a consensus than the ones from Nao. These box plots also show that the perceived authoritativeness is higher for the conditions with higher dominance for both of the robots. A Kruskal Wallis test revealed a significant effect of styles on perceived authoritativeness (Reeti : $\chi^2(1) = 8.8452$, $p < 0.01$, Nao : $\chi^2(1) = 17.541$, $p < 0.01$). In general, Reeti-Authoritative seems to be perceived as more directive than Nao-Authoritative but this difference is not significant. However, the difference of authoritativeness between Permissives Nao and Reeti is significant ($\chi^2(1) = 7.3321$, $p < 0.01$). These results validate the first hypothesis H1, that authoritativeness is expressible by robots' non verbal communicational channels. The parents were able to differentiate between Authoritative and Permissive parenting style

for both robots. There is an effect of the robot when the expression is of the Permissive style only.

B. Effectiveness

It was asked to the parents to evaluate the if the instruction given by the robot seemed effective or not. We asked the question : "For each of the given age ranges, do you think the instruction represented in the associated video would be followed?" The figure 2 shows the proportion of parents who believed that the instruction was followed for each age range & modality of robots and styles.

The first comment that can be made, is that the effectiveness is higher for children than for other ranges. As expected (H2), the authoritative style seems to be perceived as more effective than the permissive ones. However, this difference is less important for children of very young age (under 7). For children, Nao with a permissive style was the least effective, and Reeti with an authoritative style turned out to be the most. We notice that the effectiveness is on average perceived higher for adults than for teenagers.

Although subjects perceived Reeti-Authoritative slightly more effective than Reeti-Permissive the difference was not significant, $\chi^2(3) = 4.90$, $p < 0.2$. The proportion of parents finding Nao-Authoritative effective for children (7 to 11 y.o.) was 0.31 whereas the proportion finding Nao-Permissive effective was only 0.06. The difference in proportions is significant, $\chi^2(3) = 12.03$, $p < 0.001$. For Nao, we can conclude that the style influenced the perceived effectiveness significantly.

From figure 2, we can see that there is Reeti-Authoritative is more effective than Nao-Authoritative, however this difference was not found to be significant, $\chi^2(3) = 5.76$, $p < 0.10$. 36% of the parents found Reeti-Permissive to be effective whereas only 6% found Nao-Permissive effective. The difference in proportions is significant, $\chi^2(3) = 16.26$, $p < 0.001$. We can conclude on an influence of the robot on the effectiveness only when having a permissive style.

The perceived effectiveness of an authoritative Nao robot is higher than a permissive one in the context of giving a direction (H2 verified for Nao).

C. Acceptability

The participants were asked to pick between the authoritative robot, the permissive robot or neither. Among people who picked a robot, we can see in figure 3 that the proportion of people picking the authoritative robot is higher for both of the robots (Reeti and Nao). From the set of people who saw the Reeti robot expressing both styles, 58% agreed to pick this robot for their child; 35% with an authoritative style. For Nao, fewer people considered it as a companion for their child (41%), but when they did, 3 persons over 4 were opting for the authoritative style.

These results confirm our hypothesis (H3): In the context of a robot giving an instruction to the child, there is a user variability in terms of acceptability of the style of the robot (not all parents were picking the authoritative robot).

We used the Parenting Questionnaire Revised [10] to measure the parenting styles of the participants. Participants

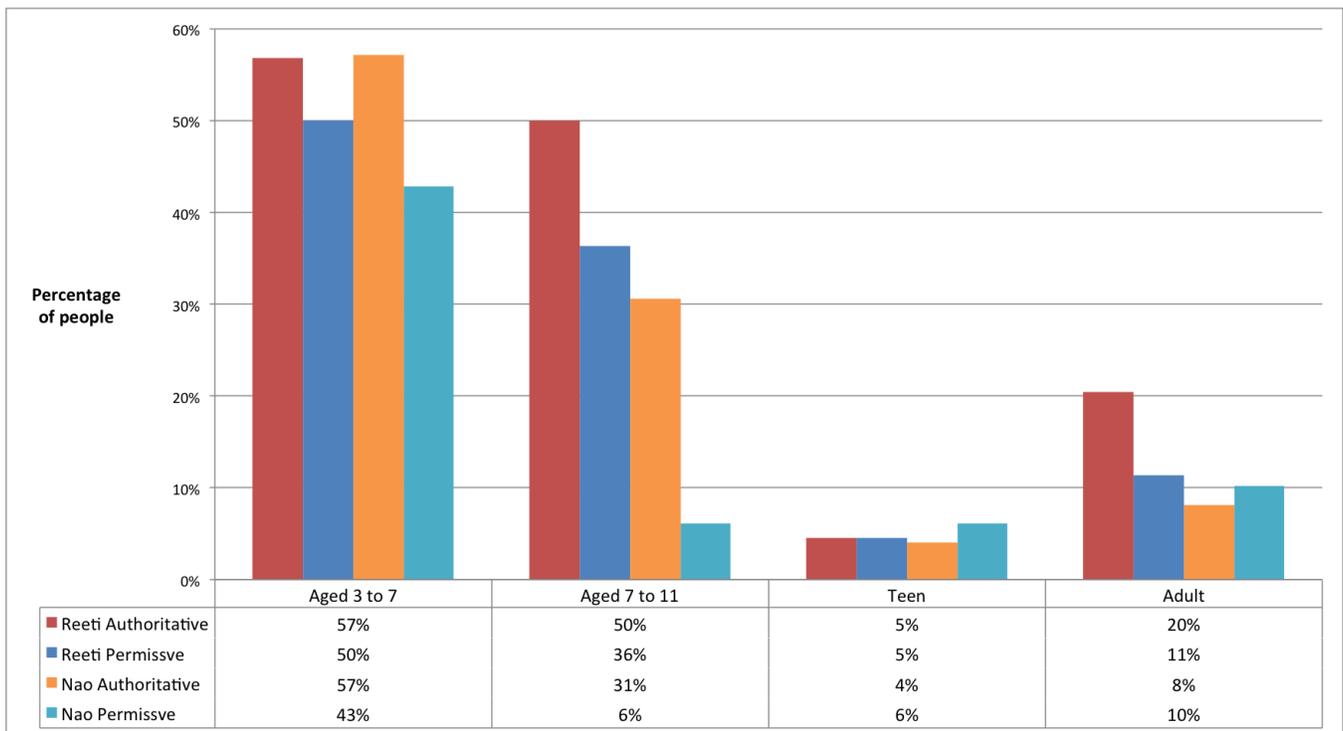


Fig. 2. Percentage of parents that believe in the Effectiveness of the robot in each modalities (for 4 ranges of age)

self-reported their habits with their children through their answers. We compared their authoritativeness and "permissiveness" score to their choices of style for the companion robot of their children. We expected a correlation; however, our hypothesis (H4) was invalid. The variability of acceptability of the style expressed by the robot turned out not to be correlated to the own style of the user. Among users who had high authoritativeness in their behavior with their children, some preferred a robot with permissive style and vice-versa. We noticed a similar distribution of choices among the whole population of parents than the one among the authoritative ones. Hence, we can recommend to use style in an end-user programming manner. choices

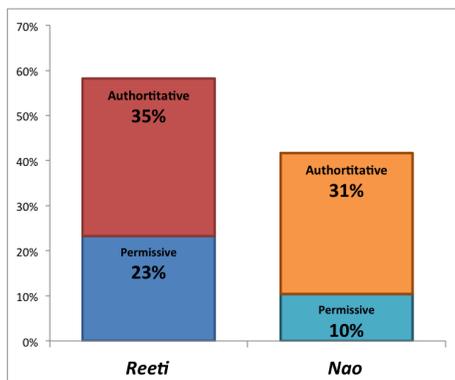


Fig. 3. Histogram of choices between the Dominant and permissive style for each robot

To conclude, we can say that there does not exist a consensus on the choice of the style for their children. Fur-

thermore, there is no correlation (direct or inverse) between the parenting style of the user and his choice as a companion for his child.

VI. CONCLUSIONS & PERSPECTIVES

In this paper, we presented a first study on expressing parenting styles by companion robots. We used non-verbal communication cues to vary the level of authoritativeness displayed by facially expressive (Reeti) and bodily expressive (Nao) robots. We proposed a questionnaire to parents about perception, acceptability and effectiveness of the companion robot while it demands a child to perform a conative effort.

Results showed that a robot displaying dominance was perceived to be more authoritative than one with less dominance. As for humans, dominance is hence a dimension of authoritativeness for robots. Users were able to recognize permissive and authoritative behaviours for both robots. The personalisation with styles lead to differences in term of choice of the style the robot should adopt for the participants' children.

Effectiveness was judged to be good enough to give orders to children under 11 years old, especially when the robot adopted an authoritative style.

We did not find that there was a correlation between the parenting style of the participant and their choices of style in the companion for their children. We think that this kind of personalization of the companion should be explicitly set by the parents for the children using end-user programming.

The next step of this work will be to test the acceptability and the effectiveness of the robots while adopting a parenting

style during a real interaction with a child. We will then evaluate the two criteria using both the parents' and children's experiences.

The current study explored psychological theories on *styles* by using classification of parenting styles to personalize the robot companion's behaviour in context. To our knowledge, the current study is the first to make this connection. Thereby, it opens up many possibilities for future research. Where personality is not context dependent, styles can be adopted according to the role (social bond between the companion and the user) and the context (eg. game, coach, teacher). Recent works have started to explore how *styles* could influence trust in social robots [26]. We believe that further work should be accomplished towards integrating styles in the design of companion robots.

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