Dance with Me! Child-Robot Interaction in the Wild

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Abstract. This paper presents the results of a singular experiment that has been conducted in a kindergarten in Japan. Four groups of ten children aged 3- to 5-year old interacted freely with the robot Pepper for about 20 min. In the first part of the experiment, the robot introduced itself to the children explaining a few basics. The children were then invited to touch the robot, to dance with it and finally to play with it freely while it was idle. Our experiment shows that regardless of the children's age, they engage easily with the robot while it was talking and moving, however children of different ages have a different perception of the robot when it is idle. Younger children consider it more as a toy while older children are more likely to attribute a meaning to its idleness.

Keywords: HRI in the wild · Humanoid · Children

1 Introduction

As social robots are rapidly proliferating our society, the technologists are faced with the challenge of designing robots that interact intuitively with the user and also fulfill the need for which they were designed: companionship, education, healthcare, physical and emotional assistance, and so on Young (1964) and Robins (2005). In this regard, a particular target group of interest is young children (less than six years). Designing social robots that interact naturally with young children is a challenging task. On one hand, children accept robots readily and are eager to project human attributes onto them. On the other hand, they get bored easily and expect interesting, novel behavior from the robot all the time. In order to meet this challenge and design robots that are fun, educational and easily accepted by a child, it is necessary to collect data on child-robot interaction in natural settings. There have already been a few such studies (Belpaeme et al. 2012, Kozima and Nakagawa 2006 and Wood et al. 2013), which have generated valuable insights. For example, it has been found that dance is a natural and intuitive mode of child-robot interaction (Espinoza et al. 2011 and Shinozaki et al. 2006). In another study, it was found that in their first encounter with a robot, young children tend to watch the robot instead of engaging with it (Güneysu et al. 2013).

To gain further insights into how young children behave towards social robots, we carried out a study by bringing Pepper robot in a Japanese nursery school, and have children (3–5 years) interact with it in different modes. In this paper, we present preliminary results from analyzing the data collected during this experiment.

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2 Objectives

There were several issues we wanted to explore in this study. To start with, we were interested in observing the behavior of children when interacting with a robot in three different free modes: instructor mode, peer mode, idle/object mode. We call these modes "free" because no instructions were specifically given to the children on the dos and don'ts with the robot. They were free to touch it, push it, play with it or ignore it. From these observations, our goal was to find answers to the following questions (among others):

(1) How do younger children who are smaller than the robot act towards it? Do they show fear?
(2) Do they act towards the robot in different ways depending on the robot's mode?
(3) Are there any gender-based differences in how children interact with the robot?

3 Experiment

Our experiment was conducted with the robot Pepper in a Japanese nursery school. The choice of the robot was motivated by its height, which is about the height of a 4- or 5-year old child. Compared to many other robot-child interaction experiments, where NAO or other similar robot that is smaller than the children was used (Güneysu et al. 2013), in our experiment the robot is seen as a peer, and not as a pet or a toy.

3.1 Participants

We worked directly in collaboration with a Japanese nursery school to organize a special event "Let us play with a robot" one afternoon. The participation was voluntary, and interested parents could register their child. The parents were informed about the content of the experiment, and their informed consent was obtained to use the data for research. The nursery school took care of the overall organization, and group compositions. We conducted four 30-minute sessions with similar structure with four different groups: 3-year olds, 4-year olds, 5-year olds, and a mixed group with 3-4-5-year olds together. Each group contained about nine to eleven children. Their parents were invited to watch but were asked to not interact with the robot or the children during the experiment. The main experiment lasted ten minutes, after which an additional 10-minute free interaction session with the robot was conducted. The timing of the interaction session was not strictly enforced and for some groups this latter session lasted up to 18 min. Except for controlling the age of the children and reproducing the same 10-minute main experiment in terms of robot motion and robot speech, nothing was controlled in our experiment, hence the terminology "in the wild".

3.2 Scenarios

To craft a scenario that would engage the children without making them bored, we divided the interaction with each group into five stages with different activities and different types of interactions:

- Stage 1: The robot introduces itself as a robot and explains that it works with motors and computers (Fig. 1 Top-Left);

Fig. 1. Snapshots of the experiment in different stages. Upper-Left: Stage 1 when the robot introduces itself; Middle-Left: Stage 2 when the children touch the robot individually or in small groups; Middle-Right: Stage 3 the robot demonstrates its ability to dance; Right: Stage 4 the robot dances with the children Bottom: Stage 5 the children interact with the robot freely

- Stage 2: The children are invited to touch the robot one at a time, or in small groups depending on the age (Fig. 1 Top-Left-Middle);
- Stage 3: The robot demonstrates its ability to dance (Fig. 1 Top-Right-Middle);
- Stage 4: The robot dances with the children (Fig. 1 Top-Right);
- Stage 5: The robot is stopped (and idle) and the children are free to touch and play with it (Fig. 1 Bottom).

These stages are illustrated in Fig. 2 with the snapshots of the experiment in each stage with different groups.

It was important that the children should know the choreography of the dance to interact freely with the robot, so we decided together with the teachers that the robot should execute a choreography that the children have already learned at the school. We chose choreographies for two different songs. The principal played the music while the teachers and the children sang and danced together.

No specific guidelines and rules were given to the children when touching and interacting freely with the robot. We only visually monitored the stability of the robot and to ensure that the children did not damage the robot accidentally. No intervention was needed throughout the experiment.

Fig. 2. Snapshot during the experiments. (a) Mixed age group during stage 1 when the robot introduce itself. Children are focused on the robot and listen to it. (b) 5 year old group during stage 2 when the children come to touch the robot. Some touched it briefly. (c) Mixed age group (3 year old) during stage 2 when the children come to touch the robot. Younger children are touching very carefully from far away. (d) 3 year old group (all age) during stage 2 when the children come to touch the robot. Elder children get closers, and are followed by younger ones. (e) 5 year old group during stage 4 when the children dance with the robot. They dance with it as a peer or an instructor but don't hold hand with it. (f) 5 year old group during stage 4 when the children dance with the robot. They dance with it, as a peer. (g) Mixed age group (5 year old) during stage 4 when the children dance with the robot. They hold hands with the robot and dance with it as a peer. (h) Mixed age group (5 year old) during stage 4 when the children dance with the robot. The child tries to look in the eyes of the robot. (i) 5 year old group during stage 4 when the children dance with the robot. They hold hands with the robot and dance with it as a peer. (j) 5 year old group during stage 4 when the children dance with the robot. They hold hands with the robot and dance with it as a peer. (k) 5 year old group during stage 4 when the children dance with the robot. They hold hands with the robot and dance with it as a peer. (l) 4 year old group during stage 4 when the children dance with the robot. They hold hands with the robot and dance with it as a peer. (m) 4 year old group during stage 5 when the children can interact freely with the idle robot. The children carefully caress and touch the robot. (n) 4 year old group during stage 5 when the children can interact freely with the idle robot. They touch and push the robot carefully. (o) 3 year old group during stage 5 when the children can interact freely with the idle robot. The children touch carefully the robot at first. (p) 3 year old group during stage 5 when the children can interact freely with the idle robot. The children realized they could move the robot by pushing its base, and push the robot in any direction. (q) Mixed age group during stage 5 when the children can interact freely with the idle robot. The children touch and push the robot. (r) Mixed age group during stage 5 when the children can interact freely with the idle robot. One child protects the robot from the other children. (s) 3 year old group during stage 5 when the children can interact freely with the idle robot. The children push it in any direction. (t) 3 year old group during stage 5 when the children can interact freely with the stopped robot. The children try to look at the face of the robot.

3.3 Robot Programming

The robot Pepper (Softbank robotics) can be programmed using the software Choregraphe, which was sufficient for our experiment as there was no real interaction requiring feedback. We used both kinesthetic teaching of the robot and manual programing for each of the Stages 1 to 4. In Stage 5, the robot was in its default idle mode, or stopped when required by the hardware.

3.4 Measure and Analysis

Each experiment was video recorded by two fixed cameras from two different angles. Some additional recordings and pictures were made manually on the spot.

The results presented in this paper are based on the notes taken during the experiments and a preliminary analysis of the video recordings. Some key frames to illustrate our findings are given in Fig. 2. Excerpts from the videos recordings of the experiments will be made available at the time of publication.

We evaluated the "fear" of interacting with the robot by the typical bodily and facial expressions of fear (Abigail et al. 2005 and Dael et al. 2013). We evaluated the interaction in Stage 5 based on the number of children interacting with the robot to obtained the percentage of total interaction as follow:

$$I_{\%} = \frac{\sum_{i=1}^{number\ of\ children\ in\ the\ group} Interaction\ time\ of\ child\ i}{total\ interaction\ time \times number\ of\ children\ in\ the\ group}$$

4 Results and Discussion

We performed a preliminary analysis of the experimental data to address the three questions mentioned above in Sect. 2. This analysis was based largely on the data from Stage 2. Snapshots of the experiments at different stages and with different age groups are shown in Fig. 2. The captions of the figures are given at the end for the ease of reading. Table 1 also summarizes the percentage of total interaction for each of the groups. Our experimental results allow us to address the three main issues raised in Sect. 2 as follows.

Table 1. Percentage of interaction with the robots during Stage 5 for each group

Groups	Age 3	Age 4	Age 5	Mixed age
$I_{\%}$	88,2%	100%	81,6%	93.4%

4.1 How Do Younger Children Who Are Smaller Than the Robot Act Towards It? Do They Show Fear?

There was a clear difference in behavior with the younger children (age 3) compared to the older ones (age 4 or 5). As can be seen in Fig. 2, the younger children were more restrained in their interaction with the robot when it was moving in the Stages 1, 2, 3

and 4. It was more difficult for the younger children to dance with the robot: not necessarily because of the robot, but because it was harder for them to remember the choreography they had learned in the school. However, in Stage 5 of the experiment, as shown in Fig. 2o, p, s and t, the younger children interacted with the robot easily. However, they did not seem to consider it as a moving or living object anymore, but rather as a large toy: moving its wheeled base around, pulling its arms and tablet, peeking under it to see the wheels, or ignoring it. They showed no sign of any fear such as avoiding the robot, getting far away from it; on the contrary all the children easily approached it and touched it without restraint when the robot was moving under restraint. Some children screamed "kowai! (scary!)", when the robot moved in the idle mode, but it was obviously more in amusement than in real fear since they got close to the robot right after. Some children clearly enjoyed the idle robot more than the other stages as can be seen in Fig. 2p, s and t (six children out of ten), while others simply ignored it temporarily as can be seen from Table 1. It is to be noted that all the children interacted with the robot, either alone or in a group. Most of the time all the children were around the robot at once.

4.2 Do Children Act Towards the Robot in Different Ways Depending on the Mode of the Robot?

In each age group, the children behaved differently in different modes of interaction. In Stages 1 and 3, when the robot was behaving as an instructor, most children, especially the older children, seem to be concentrating on listening and reacting to the robot's speech and actions as can be seen in Figs. 1(Top-Left, Right-Middle) and 2a. On the other hand, the younger children seem more puzzled and seem to be focusing on the robot's speech. In Stage 2, when the children were invited to touch the robot, most of the children touched it briefly and made verbal comments as can be seen in Figs. 1 (Top-Right, Top-Middle) and 2b–d.

Depending on the groups, the children also displayed mimetic and singular behaviors. For example, in some groups, all the children touched the robot at the same place (mimetic), mainly on the arm, as shown in Fig. 2b. In other groups, all the children touched the robot in different places (singular): on the arm, on the face, on the head, on the trunk, on the base, and so on. In Stage 4, when the children danced with the robot (Fig. 2e–l), most of the children enjoyed the dancing. Though some children seemed hesitant in touching the robot and holding hands with it, other children did not seem to care: they danced with the robot as they did with other children and seem to accept it as a peer (Fig. 2f, g, i, j, k and l), mocking it when it was making mistakes and guiding it to make proper dance moves according to the choreography (Fig. 2k). Finally, in Stage 5, most of the children interacted with the robot. As mentioned above, the younger children considered it more as an inanimate, large toy, and pushed it around (Fig. 2n, p and s). But the older children seemed to consider the robot more as a pet or a peer; patting it, protecting it (Fig. 2q–r), asking why it does not move, giving it shoulder massage when it seemed tired (a common practice in Japan that children may have learned at home), trying to make eye contact with the robot when it did not move or moved its head randomly, and showing caring behavior towards it when it was

completely stopped, asking it to move or talk "Pepper, do something! Pepper, say something!" (Fig. 1 Bottom).

4.3 Are There Any Gender-Based Differences in How Children Interact with the Robot?

In our experiment, the gender distribution of the participants was almost even in each group. We observed little gender-based differences in behavior in most of the groups in Stages 1, 2, 3 of the experiment. In Stage 4, when dancing with the robot, younger boys interacted more easily than younger girls, but older girls tended to be more proactive: getting close to the robot, and holding hands with it. However, these differences did not seem to be significant. (A statistical analysis will be presented in later research.) In Stage 5, when the robot was idle, the girls in the younger group seemed less interested than the boys, who played with the robot as can be seen in Fig. 2o, p, s and t. In other groups, children of both genders seemed to show the same interest and concerns towards the robot, and behaved towards it in a similar fashion as can be seen in Fig. 2m–q.

5 Conclusion

This experiment was very rich in findings and we are just at the preliminary level of extracting information and analyzing the results. Our experimental scenario gave almost total freedom to the children when interacting with the robot. Unlike other research on child-robot interaction, the children in our experiment were not restricted to just looking at and mimicking the robot, but they could physically interact with it freely: touch it, dance with it, hold hands with it, manipulate it, pat it, and so on. In this first paper, we presented our initial results that address some of the questions that motivated our experiments. In particular, the following points were observed:

(1) Children of younger age did not seem to fear the robot, but interacted less with it during the Stages 1–4, and interacted with it as a toy once it was idle in Stage 5.
(2) There was a significant difference in behavior depending on the activity of the robot during the different stages of the experiment.
(3) There was a significant difference in behavior during the idle mode depending on the age of the children. Younger children considered the robot as a toy, while older children considered it as a peer or a pet, and were concerned about it when it would not move.
(4) There was little to no difference in behavior between genders regardless of the age.

In the future, we are planning to analyze further the video recording to provide a quantitative analysis of the interaction and address some other issues in the field of child-robot interaction. In particular, the behavior in the different stages of the experiment needs a deeper analysis to understand when a child accepts a robot naturally, which will help us to design more intuitive child-robot interfaces. We also plan to do further experiments to address how the size and the design of the robot may or may

not influence its acceptability by the children of different ages. It is necessary also to take into account repetitive interactions over longer time periods to make a sustainable system. Confirming the findings of (Güneysu et al. 2013) we clearly observed the novelty effect with the children in our experiment. Even though Pepper is a well-known and accessible robot in Japan, most of the children in our experiment had never interacted with it directly and freely. So they showed curiosity and exploratory behavior towards it, but at the same time some children were shy and cautious while approaching it.

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