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Behavior Analysis of Children's Touch on a Small Humanoid Robot: Long-term Observation at a Daily Classroom over Three Months

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Abstract— **We have been conducting HRI (human-robot interaction) studies with the basic principle of design by immersion, which suggests the importance of researchers moving themselves into unconstrained daily-life environments. This is crucial for design and development of social robots that interact and assist people in the daily real-world. In this paper we report findings on a study where a small humanoid robot kept attending at a nursery school on a daily basis for more than three months. We focus on children's touch behavior on the robot, and conduct video analyses based on six categories related to the touch behavior. Results tell us important conditions for designing every-day robots.**

I. Introduction

The challenge for every-day robots is that controlled conditions typical of laboratory environments do not generalize well to the daily life environments where these robots need to operate. To obtain useful knowledge for the design and development of every-day robots, long-term field studies are invaluable. It is the reason why we started the RUBI project [1], [3], [4] whose goal is to design social robots in a continuous manner by immersion in educational environments. As part of this project we introduced a small humanoid robot into the Early Childhood Education Center (ECEC) at the University of California, San Diego for a total of 45 daily sessions, of approximately 45-60 minutes each.

Room-1 hosts around 12 children between 10-24 months old. We targeted the age group because it forced us to focus on non-verbal, affective forms of communication. While verbal communication plays an important role in human interaction, current technologies such as speech recognition and natural language processing are not sufficiently advanced to sustain engaging interaction for significant periods of time. On the other hand, children in the age group are capable of establishing engaging interactions for long periods of time despite their very limited verbal abilities. One of our goals was to gain a better understanding of the principles and important factors in these early forms of communication and to attempt to replicate them in social robots.

In this paper we describe findings from video analyses we conducted based on those taken over three months at ECEC. We especially focus on children's touch behavior on the robot as it is one of the most frequently observed and explicit forms of interaction between children and the robot. Furthermore, it was found that the interaction which includes children's touch on the robot was evaluated better according to the analysis of subjective evaluation by using a continuous audience response method. Regarding touch behavioral descriptions, we design a coding scheme which is consist of six categories each of which represents a different form of children's touch on the robot. Coding results tell us the transition dynamics of the number of each category's occurrences over a three-month period. They show, for instance, behavioral components which can attract children's interests longer, which is useful for design and development of every-day robots.

The structure of the paper is as follows: First, we introduce the RUBI project, and describes the Early Childhood Education Center (ECEC) where the project is being conducted. Next, we explain the reason why we focus on children's touch behavior, and then we present our coding scheme of touch with follows the results section of video analyses based on the coding scheme.

II. The RUBI Project and ECEC

This study is part of the RUBI project at the University of California, San Diego (UCSD) [1], [3], [4]. The goal of the project is to explore the use of interactive robot technologies in educational environments with the basic principle of design by immersion. To this effects two robot platforms, RUBI and QRIO are being tested on a daily bases for prolonged periods of time.

The project, which started in October 2004, is being conducted at the Early Childhood Education Center at the University of California, San Diego (Fig. 1). We decided that it was important for the researchers involved in the project to immerse themselves in the environment the robots were going to operate and thus we spent more than three months volunteering 10 hours a week at ECEC. This allowed us to establish personal relationships with the teachers, parents and children and helped us identity the challenges and the situations for robots could be helpful in a classroom environment. After the volunteering period, a small humanoid robot, QRIO (Fig. 2) was introduced to Room-1 on March 2005. The work presented in this paper is based on the first 45 days of interaction between the robot and the children.

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Fig. 1. Early Childhood Education Center

Fig. 2. QRIO, a small humanoid robot developed by Sony Corporation in 2003 which we use as a research platform.

III. Touch Behavioral Description

A. Why Touch?

Touch is one of the most explicit behaviors of children representing their interests on objects. Compared with other forms of interaction such as "look at" and "speak at", it is relatively distinguishable and easy to code even in the noisy and busy environment like Room-1.

Also we found that children's touch behavior on QRIO was correlated with people's overall subjective judgment on the *goodness* of interaction between the two. We asked five coders to assess the goodness of interaction subjectively by watching videos (which will be explained in the next section) and putting a label (1:poor-5:good) continuously. We investigated this continuous audience response method in this experimental domain and found it worked very well with high reliability [4]. We are also trying to see correlation between children's touch behavior on QRIO and coders' subjective judgment on the goodness of interaction between the two. According to the latest results, it was found that they were correlated well with each other, which suggests the importance of analyzing the touch behavior in detail.

B. Videos We Use

On the analysis presented in this paper, we use 45 days of videos taken at Room-1 between March and June in 2005. During the period, we conducted experiments on daily basis except a monthly gap in April, 2005 where we could not do experiments temporarily. Each day, a session lasted at most an hour, which was taken by camcorders.

About 90% of the experiments were conducted in a "Wizard-of-Oz" manner where an operator tele-operated QRIO from a back room separated by a one-way mirror from the experimental room.

C. Touch Coding Scheme

We use six categories below for coding touch-based interaction observed between QRIO and children.

- *(Touch) hand/arm*
- *(Touch) foot/leg*
- *(Touch) body*
- *(Touch) face*
- *Touch with objects*
- *Care-taking (ex. put a blanket on QRIO)*

IV. Results

In this section, coding results (histograms) are presented. Each of the histograms shows the number of occurrence of corresponding touch-based interaction (specified by the category) over a three-month period.

Fig. 3 presents four histograms obtained from the coding. Generally speaking, the shape of the histograms is "mountain-like", i.e., the number increases as days go by and then it decreases except the case of *Hand/Arm* where the number is not decreasing. Children tended to be precautious at the beginning period and they did not touch so often. As they got accustomed to QRIO, the number had been increasing until the peak at one-two months since the experiment started.

One interesting point is that regarding the *Hand/Arm* the number is not decreasing, which means the interaction happened regularly. It is considered that the interaction based on hands or arms could attract children's interests longer compared with others.

At the early stage children often touched QRIO's eyes, and then teachers in the class room warned them not to poke eyes because we treated QRIO as if another child there. This is considered to be a reason why the number in *Face* was decreasing.

When we think about the long-term engaging interaction between humans and robots, it is important to know behavioral factors whose occurrence is not decreasing over the longer period of time. We already discussed in Fig. 3 that children's touch on QRIO's *Hand/Arm* was one of the case. Fig. 4 shows two other examples: one is *Touch with objects* and the other is *Care-taking* behavior with touch. Regarding the *Touch with objects*, it includes such behaviors like handing an object to QRIO, playing a game like peek-a-boo with them, etc. Children were creating new ways of interaction day by day, sometimes with a help of teachers, and it led to the constant (even increasing) occurrence of behaviors belong to the category. Regarding the *Care-taking* behavior, the most frequently-observed example was putting a blanket on QRIO sometimes with saying "night-night".

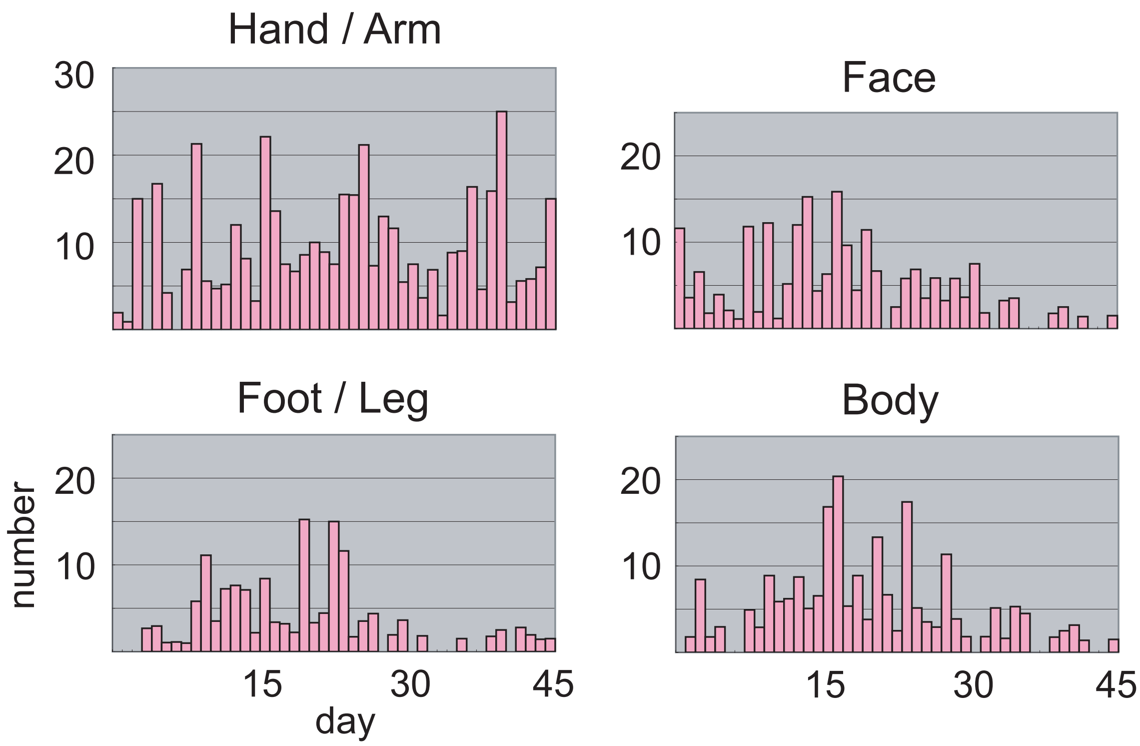

Fig. 3. The number of children's touch on QRIO with four categories each of which represents a form of touch-based interaction.

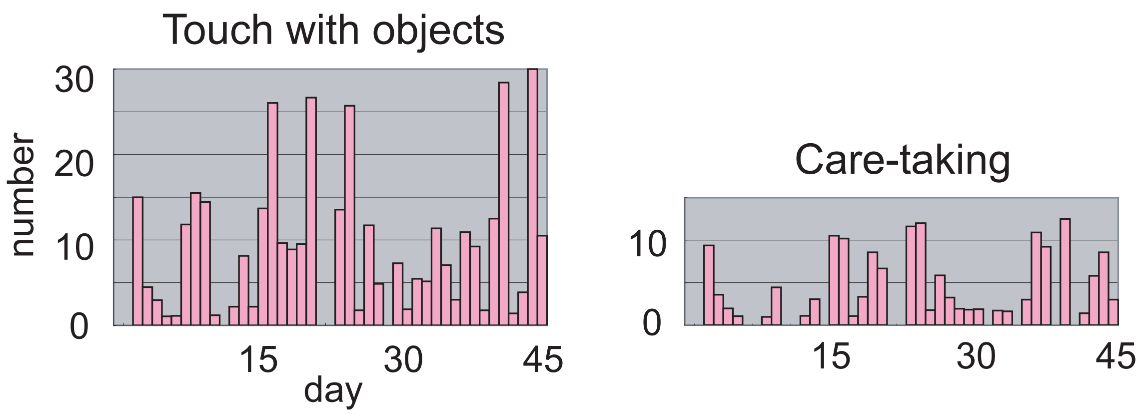

Fig. 4. Behavioral categories in which the number of occurrence was not decreasing.

Everyday, at the end of an experimental session, the operator let QRIO lies down on the floor to shut it down. Then children instantly recognized it and understood the situation, and put a blanket on it with saying ”night-night”. The important thing here is that it happened even if children had been playing with other toys before the moment, which means it could attract children's interests strongly even after 3 months period. This example implies the power of routine. Generally speaking, such applications like demonstration-dance cannot attract children's interests for a certain period of time [4]. Exploiting routine is considered to be an important factor for design and development of engaging social robots in daily life.

V. Conclusion

In this paper, we reported behavioral analyses focusing on children's touch on a small humanoid robot at a daily classroom environment. The study is part of the RUBI project whose goal is to investigate and develop every-day robots by immersion into the daily real-world. We coded videos taken over a three-month period by using a coding scheme composed of six touch-behavioral categories defined in the children-robot interaction. We found different transition in the number of occurrence at each of the categories.

In this paper, we focused on the touch behavior because it was one of the most explicit and crucial factors for realizing the *good* interaction. Behavioral coding with more general and wide-view scheme (ex. [2]) will also be valuable especially for grasping the global context which is necessary for the better daily interaction between humans and robots.

VI. Acknowledgments

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