

# Longitudinal Child-Robot Interaction at Preschool

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## Abstract

This paper reports a year-long observation of 27 typically-developing preschoolers (three-year-olds) interacting with an interactive robot, *Keepon*, which is a simple creature-like robot capable of expressing attention (by gaze/posture) and simple emotions (by body movement). *Keepon* was placed in their playroom and tele-controlled by a human operator (wizard) in a remote room. Throughout 25 three-hour-long sessions, the children showed not only individual actions, such as approach to, exploration of, and interaction with *Keepon*, but also collective social actions, where the children spontaneously and actively situate *Keepon* in their circle of, for example, playing house. This field study suggests that *Keepon*'s infantile appearance and capabilities would induce from the children (1) various prosocial behavior as if they took care of or protected *Keepon* and (2) projection of their social expectation, such as a meaning of body movement and a role in pretense play, to *Keepon*. The interaction data has been shared among the teachers and the parents for improving and motivating their child care practices.

## Introduction

In the field of pedagogical and therapeutic services for children, the caregivers have growing interest in and need for observing and analyzing children's peer interactions in their everyday situations, where their communicative competence and performance are naturally exhibited. However, children's peer interaction would certainly be one of the most difficult human activities to investigate, since it cannot easily be transcribed in a symbolic or quantitative form. Video recording helps us a lot, but the presence of a video camera (and, of course, the person who operates it) would usually spoil the natural interactions among children. As we step back the camera away from the interactants, we would then lose the rich flow of emotional and attentional exchange. How can we observe and describe the rich flow in the inter-corporal and intersubjective interactions?

We describe here our trial of utilizing an interactive robot for observing children's peer interaction in the playroom at a preschool (Fig. 1), which suggests a novel way to observe human communicative behavior in everyday situations. The robot functions not only as an observation device (e.g., video camera) but also as an interaction partner for children; here we may equate "the robot" both with "the observer" and



Fig. 1. *Keepon* in the peer interaction among children in their playroom at a preschool. (Courtesy of *Kyoto Shimbun*)

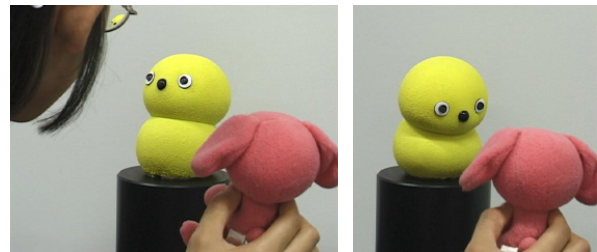


Fig. 2. *Keepon*, the creature-like robot, performing eye-contact and joint attention with a the human interactant.

with "the interactant". Next section introduces the interactive robot, which enables us to tele-participate in the interaction among children and record the interaction from its own perspective. The following section describes a year-long longitudinal observation at the preschool, where the robot interacted with 27 three-year-olds in their playroom. Final section discusses phenomenological meaning of the robot-mediated participating observation in the children's everyday situations.

## Keepon, the Robot

In order to perform non-intrusive, longitudinal, everyday interactions with children, we have built an interactive robot, *Keepon* (Fig. 2), a simple creature-like robot, which was designed to engage in emotional and attentional exchanges with children in the simplest and most comprehensive ways

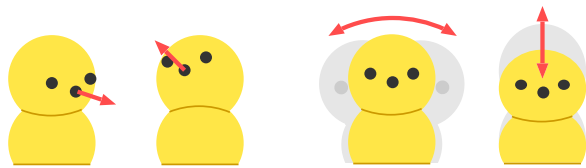


Fig. 3. *Keepon*'s possible actions: expressing attention by orienting its head (left) and expressing emotions by rocking and/or bobbing its body (right).



Fig. 4. *Keepon* interacting with a child and mother: a 27-month-old girl showing a toy to and soothing the robot.

(Kozima et al., 2004). *Keepon* has a yellow snowman-like body, 120mm tall, made of soft silicone rubber. The upper part (the “head”) has two eyes, both of which are color CCD cameras with wide-angle lenses (120 deg, horizontally), and a nose, which is actually a microphone. The lower part (the “belly”) contains small gimbals and four wires with which the body is manipulated like a marionette by four electric motors and circuit boards in the black cylinder below. Since the body is made of silicone rubber and its interior is relatively hollow, *Keepon*'s head and belly deform whenever it changes posture or someone touches it.

The simple body has four degrees of freedom: nodding (tilting)  $\pm 40$  deg, shaking (panning)  $\pm 180$  deg, rocking (side-leaning)  $\pm 25$  deg, and bobbing (shrinking) with a 15-mm stroke. These four degrees of freedom produce two qualitatively different types of actions:

- Attentive action: *Keepon* orients towards a certain target in the environment by directing the head up/down and left/right. It appears to perceive the target. This action includes eye-contact and joint attention. (Fig. 3, left)
- Emotive action: *Keepon* rocks and/or bobs its body keeping its attention fixed on a certain target. It gives the impression of expressing emotions, such as pleasure and excitement, about the target of its attention. (Fig. 3, right)

Note that *Keepon* can express “what” it perceives and “how” it evaluates the target with these two actions. These communicative functions of *Keepon*'s actions can easily be understood by human interactants, even babies and toddlers.

As a preliminary experiment, we have observed 25 typically-developing children in three different age groups, i.e., 0-year-olds, 1-year-olds, and over-2-year-olds, spontaneously interacting with *Keepon*, individually with their caregivers, as shown in Fig. 4 (Kozima et al., 2004). These three age groups exhibited qualitatively different stances to *Keepon*, namely as “a moving thing”, “a reactive system”,

and “a social agent”, respectively. Those above 2-year-old spontaneously approached and explored *Keepon* without the caregivers' assistance.

## Interaction in the Field

We observed how a group of 27 children in a class of three-year-olds (average CA 4:0 throughout the year-long observation) interacted with *Keepon* in the playroom of their preschool (Fig. 1). In each session, at around 8:30 a.m., one of the teachers brought *Keepon* to the playroom and put it on the floor with other toys. In the first 90 minutes, the children arrived at the preschool, gradually formed clusters, and played freely with each other and with *Keepon*. In the next 90 minutes, under the guidance of three teachers, the children engaged in various group activities, such as singing songs, playing musical instruments, and doing paper crafts. *Keepon* was moved as necessary by the teachers so that it did not interfere with the activities; sometimes it sat beside the teacher who was telling a story, or sat on the piano watching the children who were singing or dancing.

Throughout the longitudinal observations (25 three-hour sessions) we tele-controlled *Keepon*'s attentional expression, emotional expression, and vocalizations (of simple sound), by watching and listening to the video from *Keepon*'s on-board cameras and microphone. The children showed various spontaneous interactions with *Keepon*, individually and in a group, whose style changed over time. Here are some anecdotes about what *Keepon* experienced in the playroom. (Here, “*S<sub>n</sub>*” stands for “the *n*-th session”.)

- In *S<sub>1</sub>*, the children showed shyness and embarrassment to *Keepon*, not knowing well what it was and how they should do with it. From *S<sub>2</sub>*, they gradually started various interventions to *Keepon* — from beating to feeding.
- In *S<sub>5</sub>*, a girl NK/f put a cap on *Keepon*. When the cap was gone, a boy YT/m put his own cap on *Keepon*. In *S<sub>7</sub>*, when it was lost again, TK/m and NK/f soothed *Keepon*, saying, “Did you lose your cap?” and “Endure being without your cap.”
- In *S<sub>6</sub>*, KT/f played with *Keepon* in the outdoor playground; a boy in the 4-year-old class came to *Keepon* and told KT/f, “This is a camera. This is a machine,” but KT/f insisted, “No, this is *Keepon*'s eyes!”
- In *S<sub>8</sub>*, pointing to an insect cage, SR/f guided *Keepon*'s attention to it. In *S<sub>9</sub>*, when NR/m beat *Keepon*'s head several times, HN/f stopped him by saying, “It hurts! It hurts!” During reading time in *S<sub>11</sub>*, NK/f and TM/m came up and showed their picture books to *Keepon*.
- In *S<sub>13</sub>*, FS/m and TA/m, strongly beat *Keepon*'s head a couple of times, as if demonstrating their braveness to each other. YT/f and IR/f, observing this, approached *Keepon* and checked if it had been damaged, then YT/f said to *Keepon* and IR/f, “Boys are all alike. They all hit *Keepon*,” stroking its head gently.
- In *S<sub>16</sub>*, after a blank of a couple of sessions, NK/f came to *Keepon* and said, “We haven't see each other for a while,” as if soothing *Keepon*'s loneliness.

- In S17, YT/f taught *Keepon* some words — showing it the cap, she said, “Say, *Bo-shi*,” then switched to *Keepon*’s knitted cap and said, “This is a *Nitto Bo-shi*, that you wear in winter.” (*Keepon* could only respond to her by bobbing its body with the “pop, pop, pop” sound.)
- Also in S17, after two girls hugged *Keepon* tightly, other girls found a scar in its head. NK/f pretended giving medicine to *Keepon* with a spoon, saying, “Good boy, you’ll be all right.”
- In S19, after playing with *Keepon* for a while, IZ/m asked other children nearby, “Please take care of *Keepon*.” IZ/m managed to get an OK from KT/f, then left from *Keepon*.
- In S22, after all the children practiced a song with the teachers, several of them ran to *Keepon* and asked one by one, “Was it good?”, to which *Keepon* responded by nodding and bobbing for praise.
- In S23, NZ/m noticed *Keepon* had a flu mask and asked *Keepon*, “Caught a cold?” NK/f then put a woolen scarf around *Keepon*’s neck, then NR/m and YS/f asked NK/f, “Is he ill?” and “Got a cold?”
- In 25, NK/f gave a toy sled to *Keepon*. *Keepon* showed a preference to another toy NK/f was holding. After some negotiation, NK/f brought another sled and persuaded *Keepon*, “Now you have the same hing as mine.”

Especially during free play time (the first 90 minutes), the children showed a wide range of spontaneous actions, not only dyadic between a particular child and *Keepon*, but also *n*-adic, where *Keepon* functioned as “a mediator” (Robins et al., 2004) of interpersonal play with peers and sometimes with teachers. Since the children were generally typically-developing, they often talk empathetically with *Keepon*, as if they believed that it had a “mind”. The children interpreted *Keepon*’s responses, although they were merely simple gestures and sounds, as having communicative meanings within the interpersonal context, and exchanged the meanings among peers. In addition, in our previous observations with autistic children (Kozima & Nakagawa, 2006), we have almost never observed such peer interactions.

## Discussions and Conclusion

We reported in this paper our longitudinal observations of 27 preschool children’s peer interactions in their playroom. The peer interaction was facilitated and observed by an interactive robot, *Keepon*, which was tele-controlled by a remote operator. Qualitative analysis of the children’s dyadic interaction with *Keepon* and *n*-adic interaction mediated by *Keepon* suggests the following:

- The children were able to approach *Keepon* with a sense of curiosity and security. This was probably because the children intuitively understood the gamut of *Keepon*’s possible actions (e.g., action repertoire and range of motion) and perception (e.g., to look and to hear).
- Through the approach and exploration phases (the first several sessions), the children gradually attribute “mental states” (e.g., wanting a cap, being lonely, having pain, likes and dislikes) to *Keepon*.

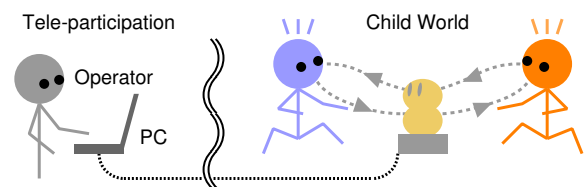


Fig. 5. Tele-participation in *Child World*: the operator subjectively experiences the *in situ* interactions, while anyone could also re-experience it from the video data.

- Some of the prosocial actions the children exhibited to *Keepon* were probably copied from what they had been done by their caregivers (e.g., feeding food or medicine, soothing and praising). Being small, helpless, and immobile, *Keepon* would be an ideal target for the children to imitate such caretaking behaviors.
- Each child exhibited a different style of interaction that changed over time, which would tell us a “story” about his or her personality and ability. This rich individual profile would not be thoroughly obtained by the snapshot result of a developmental test.

What we have done in the field is “participating observation”, where *Keepon* functioned not only as a camera but also as the agent who actually interacted with the children. The human operator tele-controlled *Keepon* and recorded the interactions from the perspective of *Keepon* as the first person of the interactions (Fig. 5). In other words, the operator transferred his or her viewpoint to the position of *Keepon*, where he or she could interact with the children by means of the robot’s simple, small appearance and comprehensive actions. Therefore, the video data contains subjective experience that *Keepon* (and so the operator) had in the interaction, which can then be re-experienced and re-interpreted by anyone including the children’s carers. To summarize, *Keepon* provides the operator with both subjective experience and interpretation of interaction *and* objective observation open to anyone to re-experience and re-interpret the interaction.

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