1. Introduction

After WWII, as nuclear families became increasingly common in Japanese homes, a great many things were lost. In child-rearing in particular, one of the merits of being raised in a large family is that it afforded experiences of communicating with a variety of people from a very young age. Additionally, in the days of larger families, ties between region and family were tight, and from these relationships emerged many learning opportunities for children. Compassion was also naturally nurtured in these societies-in-miniature. For example, grandparents, great-grandparents, and other elderly people were part of the family, and people with disabilities lived in the neighborhood, so children saw people taking care of the aged and the disabled daily. It seems likely that by witnessing such scenes daily, children of that time readily developed the mental attitude of caring for others that we call compassion and cooperation. With the increasing nuclearization of the family, these scenes have all but disappeared, and therefore in order to cultivate in children an other-oriented mindset, or what we call a "caring mindset" we are left with no choice but to artificially create similar situations through which to educate them.

How can one cultivate in young children a mindset that predisposes them to helping others? One possibility for instilling a caring mindset is to bring someone with disabilities to preschools and kindergartens and have children directly interact with them. However, in such an approach there is a risk that the disabled person might be mistakenly understood by the children as mere "teaching material", inviting a host of worrying ethical problems. In order to avoid such problems, this study examined the use of robots in place of disabled people.
work more accurately than humans. However, we decided on a methodology that overturns that image of perfection and precision by using a robot that is unable to move as well as humans. In our attempt to nurture a caring mindset in toddlers, we used a robot that cannot move around as well as a human in place of a person with disabilities, as we thought this would raise fewer ethical problems.

Regarding the relationship between robot and child, a variety of applications have been demonstrated by Robins (Robins et al., 2005), Itakura (Itakura, 2013, 2015), (Kanakogi et al., 2013) and Tanaka(Tanaka et al., 2007, 2011, 2012, 2014) et al. Especially, research by Tanaka(Tanaka and Matsuzoe, 2012) has already demonstrated the possibility of using robots as care receivers. In their research, care-receiving robot contributed to the enhancement of the children’s spontaneous learning in English instruction class. Although as far as we investigated, there are no reports of nurturing "caring mindset" using awkward robot. Thus, the first stage of our study began with observations of children's reactions during their interaction with an awkward, clumsy robot. To begin, small robots that move around at children's eye-level were fabricated for use in the observation experiment. Because this model of robot has a small number of joints, its movements are awkward in comparison with those of a human, and as a result, it has difficulty completing even simple tasks. These robots were placed in the middle of a group of children and made to perform simple actions such as opening a door and closing a curtain while the children's reactions were observed, in order to examine the possibility that the children's caring mindset could be cultivated by the robot.

2. Overview of the experimental robot

The small robot used in the experiment was Switch Science's "Rapiro" model. This robot is commercially available as a kit, and it is possible for users to program in various functions such as locomotion and remote operation.

Fig. 1 shows the appearance of this robot, and the specifications are shown in Table 1. The robot has 12 joints and 12 servomotors, one in the neck, one in the waist, three in each arm, and three in each leg. Each servomotor can be controlled by the Raspberry Pi, a small-scale UNIX computer, embedded in the robot's head. It is possible to program the robot so that the head, waist, and limbs can be moved at will. The torque for the six servomotors in the neck, hips, and legs is 3.0 [kg-cm]; for the six servomotors in both arms, the torque is 2.0 [kg-cm]. The movement speed is 0.12 [sec/60deg] and the adjustable angle is 180 [deg]. With such high servomotor torque for such a small robot, forward and backward operation is possible, in addition to small movements such as shaking and holding hands.

A variety of communication modules can be used with the Raspberry Pi. In this study, we decided to use Bluetooth for communication and developed a program that would allow operation of the robot by remote controller.

| Body size | Height: 257mm |
|-----------|--------------|
|           | Width: 196mm |
|           | Depth: 159mm |
| Main unit | ~1 kg (Assembly completed) |

Fig. 1 Appearance of Rapiro
3. Experiment on young children's reactions to small-scale robots

We conducted the experiment at a preschool by having the children interact with the robots and observing their reactions. The experiment was conducted at Hatopoppo Preschool (Awashima Gakuen) in the north ward of Tokyo. The test location was an approximately 30m$^2$ room inside the preschool. Since there are no doors on the entrance to this room and it is connected to a hallway used frequently by the children, it is a room they are allowed to freely enter. Since the experiment was conducted during normal school hours, an alert was sent out to prevent any disturbance the experiment might cause. In order to avoid causing the children any stress, preschool teachers were allowed to accompany the children as usual, and only a minimum of restriction was placed on the children's ability to enter and leave the room, thus approximating normal conditions for the duration of the experiment.

The robot was given a name children would like (Lil' Ren), as well as a hat and bowtie, as shown in Fig. 2, in order to promote a sense of intimacy. In order to foster a caring mindset in the children, the robot performed a series of tasks poorly and with difficulty. The robot performed these tasks at a task panel, which was created by folding cardboard into a triangle and joining the sides to form a three-sided pillar and attaching paper and fabric to each side to create an atmosphere of warmth. Taking Fig. 3 – 5 in turn, Fig. 3 is the door-opening scene, Fig. 4 is the laundry scene, and Fig. 5 is the curtain-opening scene. Altogether, three challenges—"open the door," "take the laundry," and "open the curtain"—were presented to the robot. As described above, this robot has 12 joints, significantly fewer than the number of joints in humans, making all these challenges quite difficult for this clumsy robot. The robot attempted the three challenges in front of the children. The robot's movements were controlled remotely by an operator who watched the robot and the children. In order to avoid attracting the children's attention, the robot operator was situated on the other side of a wall. To ensure that the experiment was conducted in an environment close to normal and to avoid causing the children stress, the students were not formally assembled, but rather the robot was placed in the free space of the door less room, and the children were allowed to freely gather around it. Additionally, regarding the robot's challenges, the children were told, "Lil' Ren has to do this alone, so just watch, okay?" and they were encouraged not to attempt to complete the tasks. The arrangement of children, robot, task panel, and robot operator is shown in Fig. 6. To facilitate observation of differences in children's reactions by age, the experiment was conducted in the following groups of children: zero-to-one-year-olds (7-19 months), one-to-two-year-olds (20-31 months), and three-to-four-year-olds (44-55 months). As for the two-to-three-year-olds (32-43 months), their class was taking place outside the preschool during the experiment, so they did not participate. The experiment was video recorded, and the video was analyzed afterwards to investigate children's reactions. The experimental setup is shown in Fig. 7.

4. Experiment results and discussion

4.1 Behavioral differences based on the distance between children and robot

For the children, this was the first time they had seen this robot, so we attempted to observe how they reacted to it in their first interaction. We assumed that whether the children accepted the robot could be determined by observing the distance between them and the robot; detailed observation of the video allowed an examination of the position and distribution of children at fixed time intervals.

(1) Observation of children's behavior immediately after meeting robot

Each group was video recorded for 20 minutes, and the first few minutes of the footage were analyzed in the following way. For 5 minutes at the start, the details of the position of robot and child were recorded every 10 seconds, to create a distribution map. Distribution maps by age at 0 seconds, 30 seconds, and 1 minute are shown in Fig. 9–11. In addition, an explanation of each symbol in the distribution diagram is shown in Fig. 8. As described above, there was no door on the room, and the experiment was conducted so that interested children could freely gather around; therefore, with children coming and going, the number and composition of the children being observed changed over time.

Fig. 9 shows the group distribution of the zero-to-one-year olds. Even after 1 minute elapsed, the children did not approach the robot, but instead circled it at a distance. Fig. 10 shows the distribution of the one-to-two-year-old group. From 0 seconds to 1 minute, they were observed to gradually come closer to the robot. Fig. 11 shows the distribution of three-to-four-year-old group. From this Figure, one can see that the children began gathering around the robot as soon as it was placed in the room.
Fig. 2 Experimental robot.  Fig. 3 Door-opening task side.  Fig. 4 Laundry task side.  Fig. 5 Curtain-opening task side.

Fig. 6 Placement overview.

Zero-to-one-year-olds  One-to-two-year-olds  Three-to-four-year-olds

Fig. 7 Experimental setup.
Fig. 8 Explanation of Symbols

(2) Time-series change of distance between children and robot

Tables 2–4 show the distance between the children and the robot by age, every 20 seconds, from the time the robot was placed in the room until 5 minutes had elapsed. Furthermore, based on data in Tables 2–4, Fig. 12 shows a time-series change in the average distance as determined by the average infant distance for fixed time intervals.

From Fig. 12, it is clear that the children's time to approach the robot gets shorter in order of increasing age: zero-to-one-year-olds, one-to-two-year-olds, and three-to-four-year-olds. Here it is shown that the zero-to-one-year-old children began gradually approaching the robot after about 80 seconds elapsed, but these results reflect the fact that the preschool teachers accompanied the children and brought them closer, and do not indicate that the children approached on their own. Therefore, it can be determined that children at this age were not able to accept the robot until the very end. Time until approach to the robot differed for one-to-two-to-year-olds and three-to-four-year-olds, roughly 40 seconds and 20 seconds, respectively. Once they had drawn close, neither group moved away from the robot until the end.
Table 2  Distance between robot and each child (zero-to-one-year-olds)

| Time elapsed [s] | 0  | 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 220 | 240 | 260 | 280 | 300 |
|------------------|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0-1 year olds    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |     |
| a                | 257| 257| 257| 257| 257| 83  | 83  | 99  | 99  | 99  | 66  | 66  | 99  | 66  | 66  | 99  |
| B                | 244| 244| 284| 284| 284| 284 | 284 | 284 | 284 | 284 | 284 | 284 | 284 | 284 | 284 | 284 |
| C                | 277| 277| 277| 277| 277| 83  | 83  | 119 | 59  | 59  | 59  | 304 | 112 | 76  | 63  | 63  | 63  |
| d                | 257| 257| 284| 284| 284| 284 | 284 | 198 | 188 | 132 | 125 | 125 | 125 | 125 | 125 | 125 |
| e                | 290| 290| 290| 290| 290| 188 | 132 | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 |
| F                | 251| 251| 251| 251| 251| 251 | 251 | 251 | 251 | 251 | 251 | 251 | 251 | 251 | 251 | 251 |
| Average          | 263| 270| 274| 271| 217| 193 | 145 | 119 | 96  | 94  | 143 | 107 | 100 | 97  | 97  | 97  | 97  |

Table 3  Distance between robot and each child (one-to-two-year-olds)

| Time elapsed [s] | 0  | 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 220 | 240 | 260 | 280 | 300 |
|------------------|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1-2 year olds    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |     |
| A                | 162| 59 | 254| 50 | 50 | 50  | 66  | 59  | 59  | 59  | 46  | 46  | 46  | 46  | 46  | 46  | 46  |
| B                | 162| 195| 53 | 53 | 53 | 53  | 53  | 53  | 46  | 46  | 46  | 46  | 46  | 46  | 46  | 46  | 46  |
| C                | 211| 264| 119| 66 | 56 | 56  | 56  | 63  | 63  | 63  | 63  | 63  | 63  | 63  | 63  | 63  | 63  |
| D                | 231| 248|     |    |    |     |     |     |     |     |     |     |     |     |     |     |     |
| E                | 241| 241| 95 | 53 | 53 | 53  | 53  | 53  | 46  | 46  | 46  | 46  | 46  | 46  | 46  | 46  | 46  |
| F                | 251| 251| 251| 251| 251| 251 | 251 | 251 | 251 | 251 | 251 | 251 | 251 | 251 | 251 | 251 |
| Average          | 201| 214| 250| 76 | 70 | 66  | 59  | 56  | 56  | 56  | 62  | 62  | 70  | 70  | 70  | 70  | 70  |

Table 4  Distance between robot and each child (three-to-four-year-olds)

| Time elapsed [s] | 0  | 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 220 | 240 | 260 | 280 | 300 |
|------------------|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 3-4 year olds    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |     |
| A                | 158| 56 | 69 | 69 | 69 | 69  | 69  | 69  | 69  | 69  | 69  | 69  | 69  | 69  | 69  | 69  | 69  |
| B                | 162| 50 | 56 | 56 | 56 | 56  | 56  | 56  | 56  | 56  | 56  | 56  | 56  | 56  | 56  | 56  | 56  |
| C                | 155| 50 | 66 | 69 | 69 | 69  | 69  | 69  | 69  | 69  | 69  | 69  | 69  | 69  | 69  | 69  | 69  |
| D                | 158| 50 | 53 | 53 | 53 | 53  | 53  | 53  | 53  | 53  | 53  | 53  | 53  | 53  | 53  | 53  | 53  |
| E                | 165| 139| 56 | 56 | 56 | 56  | 56  | 56  | 56  | 56  | 56  | 56  | 56  | 56  | 56  | 56  | 56  |
| F                | 182| 99 | 73 | 116| 116| 149 | 155 | 155 | 155 | 155 | 132 | 149 | 149 | 149 | 149 | 149 | 149 |
| g                |     |    |    |    |    |     |     |     |     |     |     |     |     |     |     |     |     |
| H                | 73  | 83 | 83 | 83 | 83 | 83  | 79  | 79  | 79  | 79  | 79  | 79  | 79  | 79  | 79  | 79  | 79  |
| i                | 76  | 76 | 76 | 56 | 56 | 56  | 76  | 69  | 69  | 69  | 69  | 69  | 69  | 69  | 69  | 69  | 69  |
| j                | 66  | 66 | 89 | 89 | 89 | 89  | 66  | 66  | 66  | 66  | 66  | 66  | 66  | 66  | 66  | 66  | 66  |
| k                | 86  | 86 | 69 | 69 | 69 | 69  | 89  | 89  | 89  | 89  | 89  | 89  | 89  | 89  | 89  | 89  | 89  |
| l                | 59  | 59 | 129| 129| 129| 129 | 66  | 66  | 66  | 66  | 66  | 66  | 66  | 66  | 66  | 66  | 66  |
| M                | 163 | 64 | 73 | 73 | 68 | 69  | 70  | 69  | 84  | 84  | 71  | 71  | 71  | 67  | 67  | 67  | 67  |
| Average          |     |    |    |    |    |     |     |     |     |     |     |     |     |     |     |     |     |     |

![Fig. 12  Time-series change in the average distance between the children and the robot](image-url)
4.2 Overall observations

The following shows the observation results for each age group from the start of the experiment (when children were presented with the robot) until about 20 minutes.

(1) Zero-to-one-year-olds

Zero-to-one-year-olds watched the robot from a distance, and although the preschool teachers gave instructions like "The robot is looking this way," they still did not approach the robot. Preschool teachers embraced one child, held the hand of another, and brought the pair up closer to the robot, but both children looked at the robot, began crying, and turned around to run away. From behavior such as this, it is reasonable to conclude that the children were afraid of the robot. Approximately 2 minutes passed from the start of the experiment before children were first able to approach the robot when accompanied by the preschool teachers. Afterward, all five children slowly approached the robot while accompanied by preschool teachers, but even then they were frightened, pulling away, hugging the teachers, and refusing to let go.

(2) One-to-two-year-olds

Initially, four of the one-to-two-year-old children showed interest in the robot, but they did not approach it. One of them was trying to approach while alternately looking back at the preschool teacher and at the robot. At about 30 seconds from the start of the experiment, one child timidly approached the robot, stroked its head, and then dropped to the back with a smile. From these behaviors, it appears that the children had an interest in the robot and thought they wanted to touch it but were still afraid. However, their fear appeared to fade with the passage of time, since at 1 minute 30 seconds from the start of the experiment, the majority of the children had gathered around the robot. After that, children voluntarily took actions such as patting the robot's head and so on. Although there were few instances of children speaking to the robot, there were situations where the children cared for the robot, as when the robot's hat was tilted forward and one child said, "Lil' Ren can't see anymore!" and adjusted the hat so that the robot's eyes were not hidden.

(3) Three-to-four-year-olds

The three-to-four-year-olds showed an interest in the robot from the beginning, asked the preschool teacher if they could touch it, and began touching it within 10 seconds of the start of the experiment. They expressed happiness with shouts of surprise and excitement, and there was no indication that they were afraid.

Certain of the children's behaviors suggested that they treated the robot the same way they would a human; in addition to the hat incident, the children also waved their hands in front of the robot's eyes.

Regarding speech, by the second half of the experiment the children were saying, "Come on!" and "You can do it!" and taking a protective stance as they cheered for the robot to complete its tasks. In addition, children were also observed to propose solutions to the robot's challenges, as evidenced when one child said, "If your hands don't work, you can kick (the door) open!" In the middle of the experiment, the robot collapsed and one worried child came forward, looking concerned, to say, "Do you want me to help you (with your tasks)?" However, they hesitated to directly touch the robot and stand it back up.

4.3 Examination

The results of the experiment show that since children ages zero to one were mostly frightened and unable to accept the robot, the use of robots for the cultivation of a caring mindset will be difficult with this age group. Children aged three to four were observed to accept the robot from the start, show interest in it, and attempt to encourage and help it. This suggests that three-to-four-year-olds already have a caring mindset to a certain degree. Children ages one to two also quickly accepted the robot, but spoke to it less and attempted to help it less than did the three-to-four-year-olds. However, from the perspective of cultivation of a caring mindset, we can say that the one-to-two-year-old children have room for growth, which suggests the possibility that caring mindset cultivation with a small-scale robot is effective from the age of approximately one to two years old.

This experiment was a simple, short exploration into the possibility of cultivating a caring mindset in children with robots. Since this experiment was conducted using time borrowed from the school day of a preschool, we were not able to conduct the experiment under proper conditions; however, one positive aspect was that the children were relaxed during the experiment. In the future, we plan to examine methodologies for cultivating a caring mindset in children by conducting experiments observing robots placed in a community of children and allowed to interact with them for longer periods of time.
5. Conclusion

In this study, we examined the use of robots to cultivate a caring mindset, or the desire to help others, in young children. A small-scale, remotely operable robot that stood at children's eye-level was manufactured. The robot was brought to a preschool and presented to the children, and an experiment was conducted by having the children exposed to this "disabled" robot that had trouble performing simple tasks, such as opening and closing doors. In this experiment, indications of how the children would accept the robot, and whether they would help the robot, were observed. The results show that children younger than 19 months were afraid of the robot and would not accept it, but children older than ages approximately one to two years old accepted the robot and were observed attempting to help it, confirming that the use of robots can contribute to the cultivation of a caring mindset.

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