

Young Children's Folk Knowledge of Robots

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Abstract

Children, in their everyday lives, encounter several types of humanoid robots. The purpose of this study was to investigate children's folk knowledge of robots using the card-choice task. In the task, both adults and five- and six-year-old children were given nine questions concerning the biological and psychological properties of robots. They were asked to choose the appropriate stimuli from among five objects including living things, nonliving things, and a robot. The results revealed that the children tended to attribute certain biological properties to the robot. These results accorded with previous results. However, in our study, contrary to previous such studies, even older children showed such a tendency. Moreover, the children were unable to choose all the cards in the same way as the adults. Thus, it can be concluded that children's knowledge of robots is incomplete. And the children's knowledge is changed by method.

Keywords: Folk knowledge, Robots, Japanese children, Card-choice task

1. Introduction

1.1 Robots and Modern Japanese Children

Several studies have been conducted to observe the distinctions between living and nonliving entities made by children (Gelman & Gottfried, 1996; Freeman & Sera, 1996). However, in recent years, as a result of modern technology, new types of objects, categorized as nonliving things, have been created. These include robotic toys such as Ugobe's Pleo and the robot cleaner, Roomba.

One of the most important characteristics of these machines is that they can move by imitating human actions. In

the future, children will most likely encounter various types of interactive robots. Nowadays, children come across many robots and robotic toys. Especially, the Japanese children will feel a close connection to robots, because Japanese animation and cartoons are full of robots, and Japanese industrial company succeeded in creating advanced robot, for example Sony's AIBO, Honda's ASIMO. Japanese children are surrounded by many types of robots; however, few studies have discussed the aspect of their extent of knowledge about these robots. In this study, we focus on young Japanese children's knowledge of robots.

1.2 Psychological Studies about Children's Knowledge of Robots

In the studies concerning about children's knowledge of robot, Kahn, Fiedman, Perez-Granados, and Freier (2006) revealed that children tend to attribute biological properties to a robot. Preschool children have participated in playing sessions with AIBO and a stuffed dog, and subsequently, in semi-structured interviews about them. More precisely, Jipson and Gelman (2007) investigated children's knowledge of robotic artifacts with experimental setting. They prepared six target items including robodog. Three- to five-year-old children participated in this study, wherein they viewed six video clips with six items appearing in each. Following each video, the children were asked questions concerning the biological and mental properties of the items. Results indicated that children of all ages are able to clearly distinguish between living and nonliving things. However, it was also seen that they tended to attribute certain psychological or biological properties to robodog.

This study is considered valuable because it focused on young children's knowledge of robots. However, it is important to conduct further studies in this area. Several studies have suggested that children's judgments depended on the stimuli as well as upon the manner of instruction by the experimenter. Doglin and Behrend (1985) investigated children's animistic judgement on non living things using various stimuli. They prepared 32 stimuli divided into 16 categories. The participants (adults and three-, four-, five-, seven-, and nine-year-olds) were shown eight photographs selected from the 32 stimuli and were asked to choose the correct photos in response to the psychological and biological questions. Contrary to the previous results, animistic judgment was not a pervasive phenomenon, and it was not the most primitive mode of conceptualization. It was observed that the five-year-olds were the most likely to respond animistically.

Richards and Siegler (1984) presented findings that children's life judgment changed with the questions put forward by the experimenter. In their study, they asked children (four- to nine-year-olds) a question that emphasized the motion state of each stimulus. The children tended to use motion information to determine the living things.

1.3 The Aim of Our Study

In view of these results, it was necessary to investigate children's judgment of robots by a method different from that of Jipson and Gelman (2007). In our study, we used a card-choice task, wherein the children were presented with appropriate stimuli since it had been pointed out that the interview method presented a wording problem, as mentioned in Jipson and Gelman's (2007) study. We used artifacts, animate objects, and a robot as the stimuli in order to clarify the children's conception of robots. The robot used in this study was a humanoid robot named Robovie (Figure 1). The concept of using a robot resembling a person was similar to that of the robot resembling a dog in Jipson's study. Furthermore, Robovie had been used in several other psychological studies (Itakura, 2006; Itakura, Ishida, Kanda, Ishiguro, Shimada, Lee, 2008; Itakura, Okanda, Moriguchi, 2008; Moriguchi, Kanda, Ishiguro, Itakura, 2010; Moriguchi, Minato, Ishiguro, Itakura, 2007) but few clarified the kind of knowledge that children have of Robovie.

If children's knowledge of robots was method dependent, we may be sure that the results would not show the same tendency as that of the previous studies. On the other hand, if children have a clear knowledge of robots, they would not be influenced by other stimuli or the experimenters' questions.

2. Method

2.1 Participants

Five-year-olds ($n = 19$, 9 boys and 10 girls, $M = 64.8$ months, $SD = 3.58$, range = 60 to 71 months), six-year-olds ($n = 21$), and adults ($n = 15$) participated in this study. Another 25 children had also participated in this study; however, they have been excluded from the final sample for the following reasons: experimental errors (2), they did not provide answers when asked to name the objects in the photographs (12), and they did not understand the choice task (11).

2.2 Materials

Five color photographs were used as stimuli (see Figure 1). These stimuli comprised two living things (a human

and a rabbit), two nonliving things (a refrigerator and a car), and one humanoid robot named Robovie (Robovie is an humanoid robot developed by ATR Intelligence Robotics and Communication Laboratory).

*** Insert Figure 1 about here ***

2.3 Procedure

Each child was tested individually in a quiet room at a nursery school. At the beginning of the session, the experimenter showed the participants the photographs of the five stimuli; subsequently, the children were asked to name the object in each photograph. If a child correctly provided the names of the objects in the photographs, he/she would be asked nine questions. The questions concerned the objects' biological and psychological properties. With regard to the biological properties, there were three physical questions (having eyes was the external physical property, while having bones and a heart were the internal physical properties) and three biological questions (can the object grow, move, and die?). Two questions pertained to the objects' mental states that involved their psychological properties (can they feel hot or feel pain?). Finally, the last question asked the participants whether or not they believed that these objects were alive. For each question, the experimenter first showed the participant all the photographs and then asked him/her the question (e.g., "which one has eyes?"). The participants were asked to choose the photographs that they thought would be appropriate for each question. Moreover, the participants were allowed to choose more than one photograph for each question. The order of the questions and photographs was randomized; however, the question of whether or not an object is alive ("which is the living thing from among these photographs?") was always asked at the end.

The same procedure was used for the adults.

3. Results and Discussion

3.1 Results and the Way of Analysis

The questions in this study pertain to whether or not children tend to attribute physical, biological and psychological properties to robots, using a card-choice task.

In the case of the children who did not respond to the name of each stimulus, most of them were unable to provide the name of the object such as "refrigerator" or "robot." Although a refrigerator is a common electronic item, the photograph of the refrigerator was not suitable. For the robot stimulus, the children did not familiar with such types of robot.

We conducted two analyses—first, we examined the age differences with respect to each question, and second, we examined whether the child chose all the items that were chosen by majority of the adults.

*** Insert Table 1 about here ***

3.2 Analysis of the Age Differences with Respect to Each Question

3.2.1 Results of Age Differences

The first analysis pertained to the age differences found in the answers for each question. The percentage of choices in response to each question is presented in Table 1. Of the nine questions, significant age differences were found for the following questions. For the question "Is the object alive?" a higher number of five-year-olds compared to the six-year-olds and adults chose the robot as the response ($\chi^2(2) = 8.63, p < .05$). Furthermore, a smaller number of five-year-olds chose the human and rabbit as a response (human: $\chi^2(2) = 9.98, p < .01$; rabbit: $\chi^2(2) = 8.86, p < .05$). With regard to the question of growth, fewer five-year-olds compared to six-year-olds and adults chose the human as a response ($\chi^2(2) = 14.19, p < .01$). Finally, with regard to the question of death, a higher number of five-year-olds chose the robot as a response ($\chi^2(2) = 7.41, p < .05$). No age differences were observed for the questions regarding mental state.

3.2.2 Discussion about Age Differences

From the age difference analysis, it was seen that five year-olds attributed some biological properties to the robot. In Jipson and Gelman's study, this was not observed for the robodog. Thus, children's biological knowledge of robots is affected by the stimuli and method. Dolgin and Behrend (1984) claimed that 5-year-olds mostly show animistic judgment. Since this study used the card-choice task, it may be determined that children cannot use the biological knowledge of robots well in the presence of several stimuli.

Children do not attribute mental properties to robots. This result is consistent with that of Jipson and Gelman's (2007) study. Children's mentalistic understanding of robots is stronger than their biological knowledge. Moreover, in our study, the presentation of the robot stimuli was changed. Thus, we may conclude that children's mentalistic knowledge of robots does not depend on the appearance.

The results of the false belief task using Robovie revealed that the children's percentage of correct answers decreased with respect to the questions including mental verbs (Itakura, et al., 2006). According to our results, the children did not attribute a mental state to the robot. Thus, this tendency resulted in a decrease in the correct answers. Children believe that robots can move but do not have mental capabilities.

3.3 *The Analysis of Similarity of Choice between Adults and Children*

3.3.1 The results of Similarity of Choice

In order to analyze the similarity of choice between adults and children, we checked the adults' choice patterns. Table 2 shows the tendency of the adults' choices. The response to the questions of eyes, movement, and bones did not show any significant tendency in the adult's choices. Hence, those questions were excluded from Table 2.

The participants were divided into two groups in each question—the children who chose items similar to the adults and those who chose different items. The number of participants in the groups was analyzed using the chi-square test with age (five year-olds, six year old and adult) and group (choice similar to adult and not similar) as the factors.

The age difference was shown following the question of growth ($\chi^2(2) = 20.559, p < .01$). The five-year-olds chose cards that differed from that of the six-year-olds and adults, which included having a heart ($\chi^2(2) = 6.59, p < .05$), feeling pain ($\chi^2(2) = 10.56, p < .01$), feeling hot ($\chi^2(2) = 22.99, p < .01$), and being alive ($\chi^2(2) = 9.23, p < .01$). The five- and six-year-olds chose cards that differed from those chosen by the adults.

*** Insert Table 2 about here ***

3.3.2 Discussion about Similarity of Choice

The adults showed a significant tendency in few of the questions, and we may say that the adults' concept of robots is ambiguous. In fact, some adults tended to attribute physical properties (having bones) to robots or car. Thus, the knowledge of robots among the adults was not homogeneous.

Children's choices are not all similar to the stimuli chosen by the adults. It is difficult for children to choose the only appropriate response from various types of stimuli. Compared with adults, children tend to attribute physical properties (having heart) to robot. They tend to attribute mental properties (feeling hot and feeling pain) to robot but do not to human being and rabbit. Children's choice may be confused by robot stimulus.

The question of having an eye provided a unique result. Two cameras, resembling eyes, were placed on Robovie's head. Robovie seems to have a face and eyes; however, none of the participants chose Robovie as a response to the question regarding eyes. Whether or not robots have eyes was not accordance among children, even among adult. Brooke and Meltzoff (2002) showed that in the second year, infants can understand the relationship between looking and the onlooker's intentions. For children and adults, "having an eye" means that the object with an eye may want to get something or think of something. In fact, having an eye is considered more of a mental attribute. However, robots do not have mental attribute. Thus, if the participants selected Robovie in response to the question of which object has eyes, then we may conclude that they did so only by judging Robovie's appearance. However, if they judged the object on the basis of its mental state, then, they did not choose the robot as an appropriate response. Engineers who want to create human like robot, may think the eye as important part for humanness. However, if people would judge the robot with the eye as a robot without mental state, having an eye will be mostly pointless.

3.4 *Future Directions of Research*

This study focused on children's knowledge of robots. Our results reveal that some amount of their knowledge is controlled by the stimuli or experimental setting. For future research, three and four-year-olds should be taken as participants. In fact, we had attempted to use four-year-olds as participants in our study, but they were unable to understand the choice task. Even among five- and six-year-olds some children have difficulties to understand our task. Thus, the stimuli and tasks should be refined for younger children.

Cultural and individual differences should also be taken into consideration. In fact, the extent of children's knowledge about robots is not very clear. We need to further investigate such knowledge. Hatano and Inagaki (1994) demonstrated the relationship between having biological knowledge of a rabbit and having the experience of feeding a rabbit. The regular use of a computer and the possession of a robotic toy might be related to a child's knowledge about robots. Tanaka, Cicourel and Movellan(2007) considered interactions between children and humanoid robot. Robot placed in classroom at childhood education center for 5 months. The end of the session, children (10-24 months) treated the robot as a peer, and they showed care taking behaviors toward the robot. Interactive experiences with robot in group may increase children's social behavior toward robot, because they

can watch other children's actions toward robot.

With regard to cultural differences, industrial countries such as Japan or U.S., many children are familiar with electronic gadgets, computers and robots. Therefore, children living in industrial countries will view robotics or mechanics differently from those in developing countries. In our study, participants are only Japanese. We need cross-cultural researches.

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Table 1 Frequency and Percentage of Chosen of Participants in Each Question for Each Objects in 5,6 Years-olds and Adults.

| Objects | age | Questions | | | | | | | | |
|--------------|--------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| | | Eye | Move | Grow | Die | Heart | Bone | Feel Pain | Feel Hot | Alive |
| Human Being | 5 | 17 0.89 | 11 0.58 | 11 0.58 | 15 0.79 | 18 0.95 | 17 0.89 | 10 0.53 | 10 0.53 | 19 1.00 |
| | 6 | 21 1.00 | 18 0.86 | 20 0.95 | 18 0.86 | 21 1.00 | 20 0.95 | 14 0.67 | 15 0.71 | 21 1.00 |
| | Adults | 15 1.00 |
| Rabbit | 5 | 19 1.00 | 11 0.58 | 14 0.74 | 18 0.95 | 14 0.74 | 16 0.84 | 10 0.53 | 10 0.53 | 18 0.95 |
| | 6 | 21 1.00 | 17 0.81 | 18 0.86 | 20 0.95 | 18 0.86 | 19 0.90 | 15 0.71 | 12 0.57 | 21 1.00 |
| | Adults | 15 1.00 | 15 1.00 | 15 1.00 | 15 1.00 | 15 1.00 | 15 1.00 | 14 0.93 | 14 0.93 | 15 1.00 |
| Robot | 5 | 9 0.47 | 14 0.74 | 5 0.26 | 6 0.32 | 5 0.26 | 2 0.11 | 8 0.42 | 8 0.42 | 7 0.37 |
| | 6 | 16 0.76 | 20 0.95 | 4 0.19 | 2 0.10 | 4 0.19 | 5 0.24 | 6 0.29 | 5 0.24 | 9 0.43 |
| | Adults | 10 0.67 | 13 0.87 | 0 0.00 | 1 0.07 | 0 0.00 | 3 0.20 | 1 0.07 | 1 0.07 | 0 0.00 |
| Refrigerator | 5 | 2 0.11 | 0 0.00 | 2 0.11 | 3 0.16 | 2 0.11 | 1 0.05 | 4 0.21 | 4 0.21 | 2 0.11 |
| | 6 | 1 0.05 | 5 0.24 | 2 0.10 | 1 0.05 | 0 0.00 | 2 0.10 | 2 0.10 | 3 0.14 | 1 0.05 |
| | Adults | 0 0.00 | 3 0.20 | 0 0.00 | 1 0.07 | 0 0.00 | 0 0.00 | 0 0.00 | 0 0.00 | 0 0.00 |
| Car | 5 | 2 0.11 | 17 0.89 | 4 0.21 | 3 0.16 | 2 0.11 | 1 0.05 | 5 0.26 | 5 0.26 | 2 0.11 |
| | 6 | 7 0.33 | 19 0.90 | 1 0.05 | 1 0.05 | 0 0.00 | 2 0.10 | 6 0.29 | 9 0.43 | 2 0.10 |
| | Adults | 0 0.00 | 10 0.67 | 0 0.00 | 1 0.07 | 1 0.07 | 4 0.27 | 0 0.00 | 0 0.00 | 0 0.00 |

Table 2 Items and Features in each Question based on Adult's Choice

| Objects | Questions | | | | | |
|--------------|-----------|-----|-------|-----------|----------|-------|
| | Grow | Die | Heart | Feel Pain | Feel Hot | Alive |
| Human Being | yes | yes | yes | yes | yes | yes |
| Rabbit | yes | yes | yes | yes | yes | yes |
| Robot | no | no | no | no | no | no |
| Refrigerator | no | no | no | no | no | no |
| Car | no | no | no | no | no | no |

"Yes" means chosen item by many adult participants. "No" means not chosen.

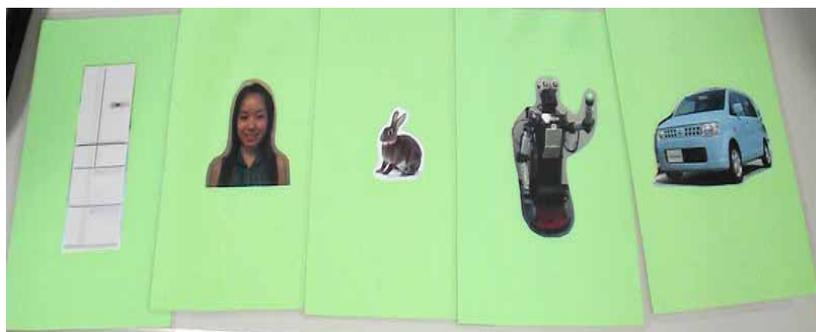


Figure 1. Photographs used in the study