Social Acceptance of a Childcare Support Robot System*

Masahiro Shiomi, *Member, IEEE* and Norihiro Hagita, *Member, IEEE*

***Abstract*—This paper investigates people's social acceptance of a childcare support robot system and compares their attitudes to two childcare technologies: anesthesia during labor and baby food (processed food and formula milk), which includes powdered milk and instant food for babies and toddlers. To investigate their social acceptance, we developed scales from three points of view: *safety and trustworthy*, *diligence*, and *decreasing workload*. For this paper, our participants were comprised of 412 people located through a web-based survey and 14 people who experienced the prototype of our childcare support robot system. They answered questionnaires about our three developed scales and an *intention to use* scale to investigate their social acceptance toward childcare support technologies. The web-based survey results indicate that our system's concept was evaluated lower than current childcare support technologies, but people who experienced our system prototype evaluated it higher than those who filled out web-based surveys.**

I. Introduction

Low worldwide birthrates are critical problems in developed countries, which are rapidly becoming extremely old societies. To increase birthrates, societal childcare support is essential. We believe that robotics can support childcare workers, but recent robotics research works mainly focus on the support of the elderly people [1] [2] [3] to solve the approaching aging society problem; childcare support using robotics technologies has received relatively less focus. We believe that childcare support must be considered equally (or more) critical as elderly care to realize the sustainable future development of social structures.

Several robotics researchers have started to develop robotics systems for nursery schools or kindergartens. For example, sensor networks or wearable sensors recognize children behaviors in kindergarten environments [4] [5]. Hieida et al. developed a social robot that physically interacts with children in a kindergarten [6]. Fink et al. investigated the effectiveness of a robotic toy box that motivates young children to pick up their toys [7]. Tanaka et al. proposed a care-receiving robot to support education [8].

However, the above research focused less on childcare support from the viewpoints of childcare workers, even though they contributed to the understanding of children's behaviors. Shiomi et al. investigated the importance of a childcare support robot system, but their system remains in a preliminary stage [9]. To realize a childcare support system, we must investigate the needs of childcare workers and construct a way to objectively measure the social acceptance of such systems. But such research works are also less focused on similar childcare support systems, even though researchers have mainly focused on measuring the social acceptance of robot systems with elderly people [1] [10].

In this paper, we investigate through questionnaires the social acceptance of people toward childcare support robot systems from various viewpoints. First we interviewed childcare workers at nursery schools to identify their needs. Based on these interview results, we developed a prototype of a childcare support system that records and indexes children's daily activities using such sensor information as the positions of children (Fig. 1) and a robot to entertain them when childcare workers are too busy. We also developed scales to investigate attitudes toward childcare support technologies to compare the social acceptance of new technologies and existing technologies. We identified participant perceptions by comparing several technologies and unveiled the essential factors that increase social acceptance.

To evaluate the validity of our developed scales and to investigate the social acceptance of a childcare support robot system, we conducted two kinds of experiments: a web-based survey and a field trial. The former investigated the validity of our developed scales and compared social acceptance between our childcare support robot system and two existing childcare support technologies: anesthesia during labor and baby food, which includes powdered milk and instant baby food. The latter investigated whether the experiences of using our childcare support robot system increased people's social acceptance of it.

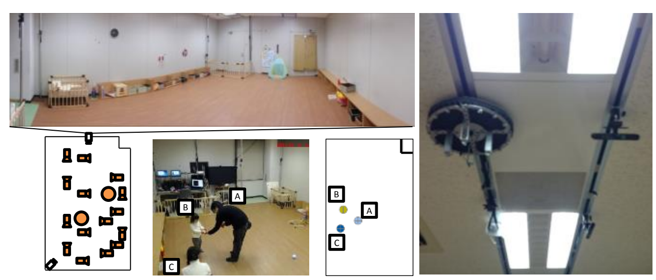

Figure 1. Intelligent playroom and sensors attached to ceiling

II. Design of Childcare Support System

A. Interviews with childcare workers at nursery schools

What kinds of childcare support do childcare workers need? We interviewed 26 teachers at three nursery schools,

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M. Shiomi and N. Hagita are with ATR, Kyoto, 6190288, Japan. (e-mail: { m-shiomi, hagita}@atr.jp).

explained the purpose of this research, and asked them what kinds of support they want for their work.

We identified two kinds of needs for childcare support. One is to help with their paperwork, including recording children's activities at nursery schools. They are interested in such sensor data as recorded and provided by cameras or human tracking systems because such information would be helpful when they observe children's daily activities. Even if they cannot directly monitor children's activity when they are too busy, the system can show what the children are doing. Note that some nursery schools are already using cameras to record daily activities for security purposes, but such systems have not been expanded to support office functions. Of course, some negative responses are related to the dependence on the system; childcare workers expressed concerns about the long-term ramifications. A few teachers worried that reliance on such systems might reduce the amount of proper care and attention from teachers about childcare.

The next need we identified concerns entertaining children and keeping them occupied. Our participating childcare workers reported that even if a system can entertain children for just a few minutes, they might benefit during hectic times. Childcare workers seemed to imagine such robots as intelligent toys. Already several intelligent toys that resemble smartphones are used to entertain children. This influences the use of robots for childcare support. Several childcare workers expressed reservations about using such robots due to privacy concerns, similar to using sensor data to record children's daily activities.

B. System overview

Based on the above interviews, we set two design policies for our childcare support robot system. The first supports office works, especially recording and indexing children's daily activity in schools. We believe that the completely autonomous indexing of children's daily activities is difficult due to the limitations of current technologies, but indexing some of data and recording most of the data will benefit paperwork. The second design policy uses a robot to entertain children. Even though children might only pay attention to the robot for a few minutes, childcare workers might benefit during busy situations, such as changing diapers.

To prove our concept, we built a prototype of an intelligent playroom (Fig. 1) in which we placed toys and books. 15 depth sensors were put in the ceiling to track people in the environment [11]. We also installed 32 microphones to record the sound of the children and the parents in the room (Fig. 1, right). The room was about 40 m^2, big enough to accommodate more than 10 people. Since the system remains under development, it only records positions, videos, and sounds; indexing children's activities is future work.

We also installed a ball-type toy robot named Sphero to investigate how children interact with it. The robot was tele-operated in some pre-defined behaviors, i.e., the Wizard of Oz style [12]. We defined the behaviors to tempt children to chase the robot, which eluded them. Thus, the robot briefly entertains the children.

III. Experiment I: Web-Based Evaluation

We conducted an experiment by a web-based survey of people's perception of a robot system that performs childcare support. We evaluated the validity of our developed scales that measured the attitudes of childcare support technologies.

A. Hypothesis and predictions

Even though social robots are slowly spreading into the world, childcare support robotics technology remains relatively unknown for ordinary people. Such new concepts or technologies basically suffer from lower social acceptance than current technologies. For example, even though processed baby food or formula milk is commonly used in the world, its social acceptance fell when new technologies were introduced in Japan. The reasons for the low social acceptance of new technologies are complicated because most people have no experience using them, and so they cannot imagine whether they are safe and/or beneficial. Using such new technologies might not be accepted by conservative people; others might feel that people who use them are irresponsible. For example, anesthesia during labor is a recent technology that supports parents and childcare contexts in Japan. One research work investigated its social acceptance and the reasons why mothers choose anesthesia during labor [13].

Based on these considerations, we expect people to have low social acceptance of childcare support robot systems because they are not very common in the world and they have never used them. Even though our hypothesis assumes negative results for current childcare support robot systems, investigating such impressions is crucial to understanding the current situations for such systems. Therefore we made the following hypothesis:

Prediction 1: People will have lower social acceptance for a childcare support robot system than current childcare support technologies**.**

B. Participants

Our survey included 412 Japanese people (405 females and 7 males), half of whom have preschool children, and the rest are licensed to work in nursery schools.

C. Procedure

In our online survey, participants answered questionnaires about three kinds of childcare support technologies: anesthesia during labor, baby food, and childcare support robot systems. For each technology, we briefly explained the meaning of our three examples: e.g., "baby food includes powdered milk and instant baby food." For the childcare support robot system, we prepared two images to explain our two concepts because this system is newer for participants than anesthesia during labor and baby food.

D. Measurements

We measured intention to use because in studies of the acceptance of new technologies [14] and social robots [15] [16], it is modeled and indicates social acceptance. We applied three kinds of scales to investigate more detailed attitudes about childcare support technologies: safety, diligence, and workload. In this research, we prepared different kinds of childcare support technologies and added a short description to each questionnaire aspect, depending on the technologies, e.g., "if you or your partner has a baby" or "if you or your partner becomes parents."

1) Intention to use

For this measurement, we adapted three items from Heerink et al. [1], including, "I'm planning to use a childcare support robot system for the next few days."

2) Safety and trustworthy

In the childcare context, the safety and trustworthiness of a technology are considered essential factors by ordinary people. For example, in a baby food context, parents believe such processed food is healthy and safe for their children; these feelings of safety and trustworthy are needed to disseminate a technology into the world. Therefore, we constructed a scale to investigate the *safety and trustworthy* of our childcare support technologies by three distinct items of trustworthiness, cleanness and safety, and anxiety. Note that X changes depending on the following conditions: anesthesia during labor, baby food, or a childcare support robot system.

- If I give birth or become a parent, I will trust using X.
- Using X will make childbirth (anesthesia during labor) or parenting (baby food, or a childcare support robot system) safe and sanitary.
- Using X will decrease my anxiety about childbirth or parenting.

3) Diligence

We believe that diligence is one essential factor for childcare support technologies. If parents feel that using them is not diligent, or if they are concerned that their friends or family might react negatively, they might avoid such technologies. Note that we avoid discussing which views are better for childcare because that debate depends on many factors. Therefore we measured the feelings of diligence about new technology in this research context by constructing a scale to investigate the *diligence* of childcare support technologies that accept the labor related to childcare and the feelings of the surrounding people by five distinct items. A higher value in this scale indicates negative attitudes about a technology from diligence viewpoints, unlike other scales.

- If I am a parent, the non-use of X is quite natural.
- Using X negatively affects parents.
- Since I think that mothers should experience natural childbirth (anesthesia during labor) or parenting (baby food, or a childcare support robot system), X should not be used.
- Since diligence during childbirth or parenting increases affection for children, X should not be used.
- Using X will make negative impressions on others.

4) Decreasing workload

One reason for using childcare support technologies is to decrease the parental workload. Baby food decreases the parental burden and provides nutrition to children. Since anesthesia during labor also decreases the maternal physical load and pain in childbirth, protecting the physical welfare of mothers after childbirth is important. Therefore, we constructed a scale to investigate the *decreasing workload* of childcare support technologies, positive effects on their children, and convenience by four distinct items:

- The use of X will decrease the physical load in childbirth (anesthesia during labor) or parenting (baby food, or a childcare support robot system).
- Parents should use X to decrease the load of childbirth or parenting.
- Decreasing the load on parents who use X will benefit children.
- Since X will be convenient, it will decrease my load in childbirth or parenting.

5) Reliability of measurements

The reliability levels of *intention to use* and the proposed scales were tested with Cronbach's alpha statistics, and the results for each fell within a solid range: α =0.96, 0.95, and 0.97 for *intention to use* about anesthesia during labor, baby food, and childcare support robot, α =0.80, 0.82, and 0.87 for s*afety and trustworthy* about anesthesia during labor, baby food, and childcare support robot, α =0.90, 0.91, and 0.88 for *diligence* about anesthesia during labor, baby food, and childcare support robot, and α =0.80, 0.84 and 0.87 for *decreasing workload* about anesthesia during labor, baby food, and childcare support robot. Since the scales are generally considered reliable if Cronbach's exceeds 0.80, we believe that our measurements are all reliable.

E. Results

1) Verification of hypothesis

Figure 2 shows the results of each scale among the conditions. We conducted a one-factor within subject ANOVA for each scale.

For *intention to use*, we found a significant difference among the conditions (F (2, 410) = 165.57, p<.001, partial η^2=.287). Multiple comparisons with the Bonferroni method revealed significant differences: baby food > anesthesia during labor (p < .001) and baby food > childcare support robot (p < .001). A significant trend was found between anesthesia during labor and childcare support robot (p = .072)

For s*afety and trustworthy*, we found a significant difference among the conditions (F (2, 410) = 84.82, p<.001, partial η^2=.171). Multiple comparisons with the Bonferroni method revealed significant differences: baby food > anesthesia during labor (p < .001), baby food > childcare support robot (p < .001), and anesthesia during labor > childcare support robot (p < .001).

For *diligence*, we found a significant difference among the conditions (F (2, 410) = 202.87, p<.001, partial η^2=.330). Multiple comparisons with the Bonferroni method revealed significant differences: baby food > childcare support robot (p < .001) and anesthesia during labor > childcare support robot (p < .001). No significant difference was found between baby food and anesthesia during labor (p =.954), For *decreasing workload*, we found a significant difference among the conditions (F (2, 410) = 130.98, p<.001, partial η^2=.242). Multiple comparisons with the Bonferroni method revealed significant differences: baby food > anesthesia during labor (p < .001), baby food > childcare support robot (p < .001), and anesthesia during labor > childcare support robot (p < .001).

These results show that people have lower social acceptance for childcare support robot systems (without intention to use anesthesia during labor) than current childcare support technologies, i.e., baby food and anesthesia during labor. Therefore, prediction 1 was supported.

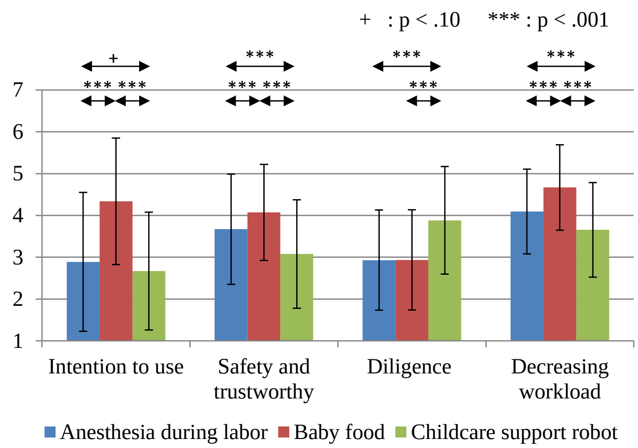

Figure 2. Questionnaire results (averages and standard deviations) of web-based survey

2) Correlations between each scale

To investigate the relationships among the scales, we calculated their Pearson correlation coefficients (Tables I~III). In all conditions, the correlations showed similar trends. We found positive correlation coefficients among *intention to use*, *safety and trustworthy*, and *decreasing workload*. We also found negative correlation coefficients between *diligence* and other scales. The high value of this scale indicates that people have negative attitudes about childcare support technologies from *diligence* viewpoints, and therefore these results might be appropriate. People with high social acceptance do not have negative attitudes from a *diligence* viewpoint.

We also investigated the correlation coefficients among childcare technologies. All of the items showed low correlation (0.2~0.4) except one combination; *diligence* between anesthesia during labor and baby food showed a quite high correlation (0.998). This result indicates that people have quite similar *diligence* toward anesthesia during labor and baby food, even though the other scales are significantly different.

TABLE I. CORRELATIONS OF ANESTHESIA DURING LABOR

Variables	1	2	3	4
1. Intention to use	-	-	-	-
2. Safety and trustworthy	.721**	-	-	-
3. Diligence	-.004	-.141**	-	-
4. Decreasing workload	.499**	.651**	-.162**	-

**: p<.01

TABLE II. CORRELATIONS OF BABY FOOD

Variables	1	2	3	4
1. Intention to use	-	-	-	-
2. Safety and trustworthy	.744**	-	-	-
3. Diligence	-.401**	-.352**	-	-
4. Decreasing workload	.507**	.526**	-.422**	-

**: p<.01

TABLE III. CORRELATIONS OF CHILDCARE SUPPORT ROBOT

Variables	1	2	3	4
1. Intention to use	-	-	-	-
2. Safety and trustworthy	.768**	-	-	-
3. Diligence	-.250**	-.261**	-	-
4. Decreasing workload	.550**	.665**	-.102**	-

**: p<.01

IV. EXPERIMENT II: FIELD EVALUATION

We also conducted a field study experiment on people's social acceptance perceptions of a robot that performs childcare support. The difference from our first experiment is that the participants experienced a prototype of our childcare robot system before answering questionnaires.

A. *Hypothesis and predictions*

As we predicted, people have low social acceptance toward childcare support robots based on a web-based survey. However, we expected that actually using a real system would increase social acceptance. Since our web-based survey did not investigate experiencing such effects, we conducted a field study that allowed children and parents to experience our intelligent playroom and made the following hypothesis:

Prediction 2: People who experience our childcare support robot system will feel greater social acceptance toward it than people who did not experience it.

B. *Participants*

Thirty people (14 parents and 16 preschool children) participated in our experiments. Parents were paid 4,000 yen (about 32.85 dollar) for their participation. 14 parents (12 women and 2 men) answered questionnaires.

C. *Procedure*

In the experiment, we asked participants to act freely in the environment for two hours. The first hour was used for the acclimatization of the children. In this time period, we explained the concept of our research and introduced sensing systems, such as a human tracking system. In the second hour, we showed the robot and started its tele-operation to investigate interactions between children and it. After the two-hour sessions, the parents answered questionnaires which included the developed scales.

D. Measurements

In this experiment, we measured the same four scales of the first experiment about a childcare support robot: *intention to use*, *safety and trustworthy*, *diligence*, and *decreasing workload*. We also interviewed the parents to identify what kinds of childcare support they wanted.

E. Results

1) Reliability of measurements

We again tested the reliability levels of the intention to use and our proposed scales with Cronbach's alpha statistics, and the results for each fell within a good range: α =0.78 for *intention to use* childcare support robotics, α =0.73 for s*afety and trustworthy* for childcare support robotics, α =0.85 for *diligence* about childcare support robotics, and α =0.89 for *decreasing workload* about childcare support robotics. Even though some scales were less than 0.80 but close to it, we believe that our measurements remain reliable.

2) Verification of hypothesis

We conducted t-tests for each measurement about childcare support robots between a web-based survey and a field study (Fig. 3). For *intention to use*, the averages were 2.67 (S.D., 1.41) and 4.76 (S.D., 1.13). We found a significant difference among the conditions ($t(424)=-5.50$, $p<.001$). For s*afety and trustworthy*, the averages were 3.08 (S.D., 1.30) and 5.00 (S.D., 0.87). We found a significant difference among the conditions ($t(424)=-5.50$, $p<.001$). For *diligence*, the averages were 3.88 (S.D., 1.29) and 2.21 (S.D., 1.07). We found a significant difference among the conditions ($t(424)=4.80$, $p<.001$). For *decreasing workload*, the averages were 3.66 (S.D., 1.13) and 4.76 (S.D., 1.24). We found a significant difference among the conditions ($t(424)=-3.59$, $p<.001$). Therefore, prediction 2 was supported.

3) Observed behaviors

During the experiments, the children freely played in the environment, basically with their parents, but also with other children or other parents. Parents were talking or caring for their children. Thus, they spent two hours in the environment, similar to usual playrooms.

When the robot is moving around, most of the children were entertained by it. Toddlers chased the robot and tried to capture it. Some children interacted with the robot for more than 30 minutes (Fig. 4). A few children wanted to stay in the environment even after the experiment had ended, suggesting the potential success of an intelligent playroom.

4) Interview results

We interviewed our participants to scrutinize their attitudes about our childcare support robotics system. All of the participants positively evaluated the sensing system because such sensor data will lead to greater understanding of children's activity, even though they expressed concerned about the privacy risks of the recorded data. They also positively evaluated the use of the robot after observing its interactions with the children because they could easily imagine scenes where they are too busy to entertain their children or to distract them. The robot interacted with or entertained their children for a few minutes or more by moving around; parents seemed to realize that it provides properties that such intelligent toys as smartphones cannot.

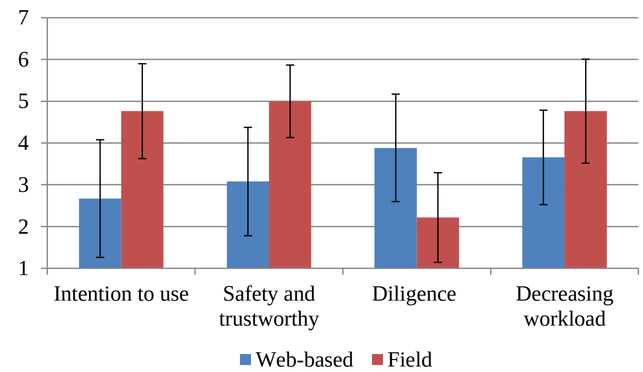

Figure 3. Questionnaire results (averages and standard deviations) about childcare support robot from web-based survey and field study

Figure 4. Scene where a child follows a robot in intelligent playroom

V. Discussion

A. Design implications

This study showed that experiencing our prototype childcare support robot system increased its social acceptance. Installing such a system in the real world might be an important future approach. On the other hand, it will be difficult to transfer such experiences to others. How to increase the social acceptance of childcare support robotics is an important question to grow this research field. A long-term field trial with our system to investigate its effectiveness is needed as future work.

This study also confirms that people did not have strong opinions about using childcare support technologies such as baby food and anesthesia during labor. In particular, anesthesia during labor seems to be less accepted in Japan; some scales showed similar low values for childcare support robotics. This might indicate the difficulties of introducing and using new technologies in childcare contexts in Japan.

One important contribution of this study is that we made scales and experimentally tested their reliability through both a web-based survey and a field study. These scales enable robotics researchers to investigate social acceptance from various points of view with other kinds of childcare support robot systems. These scales are also useful to measure the differences of social acceptance toward childcare support technologies among ages, cultures, and so on. Investigating culture differences would be interesting, especially in countries with positive attitudes to anesthesia during labor.

B. Limitation

Our ability to generalize field trial findings is limited for several reasons. First, we did not control well for the comparison between the web-based survey and the field study, such as the number of participants and background knowledge. These differences limit the interpretation of our experimental results. In particular, for a web-based survey, video stimuli must be prepared to provide knowledge about childcare support robotics. Positive bias in the field study might also exist because people who did not have positive feelings to childcare support robotics might have low motivation to participate in our experiment. The hugely unbalanced gender representation (almost all women) in our experiments might also bias the effects.

VI. Conclusion

This paper addresses whether people will accept childcare support robotics from various points of view by comparing current childcare support technologies through a web-based survey and a field study. To investigate people's social acceptance of childcare support technologies from various points of view, we developed scales to investigate the essential factors related to using childcare support technologies from three perspectives: *safety and trustworthy*, *diligence*, and *decreasing workload*. Our experiment results from a web-based survey indicate that people showed lower social acceptance toward childcare support robotics than current childcare support technologies (baby food and anesthesia during labor). However, the experiment results from a field survey indicate that people who experienced our system showed higher social acceptance for childcare support robotics than people who did not experience it.

Acknowledgments

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