Social Acceptance toward a Childcare Support Robot System: web-based cultural differences investigation and a field study in Japan

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This paper investigates people's social acceptance of a childcare support robot system and compares it with existing childcare technologies (anesthesia during labor and baby food, i.e., processed food and formula milk) through web-based questionnaires between Japan and USA and a field study in Japan [1][1]. We investigated social acceptance through four scales: *intention to use*, *safety and trustworthiness*, *negative attitudes*, and *decreasing workload*. For this paper, our participants included 400 people (200 from each country) in Japan and USA located through a web-based survey who answered questionnaires about the four scales to investigate their social acceptance of childcare support technologies. Our web-based survey results indicate that our system's concept was evaluated lower than current childcare support technologies in both Japan and USA. We also conducted a field trial with 30 additional people in Japan and through their actual experiences investigated their evaluations of the prototype of our childcare support robot system.

Keywords: childcare support, social acceptance, robot for children

1. Introduction

Falling birth rates and aging populations are common problems in developed countries, including Japan and Germany. Robotics research works continue to focus on the physical and mental supports of elderly people. Many robotics researchers have developed robotics systems and investigated their effectiveness because this research is essential to support such societies and to enhance the abilities of seniors or their caregivers in various daily environments. For example, Yu et al. investigated the effects

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[1]This paper is an extended version of a previous work [1] and contains additional experimental results and more detailed discussions.

of a social assistive pet robot with elderly people with dementia from the viewpoint of improving their moods and stimulating interaction [2]. Shiomi et al. developed an autonomous wheelchair robot to support the movement of seniors and concluded that their robot is preferred over human caregivers from the viewpoint of the simplicity of making requests [3]. Iwamura et al. developed a shopping assistant robot and reported that a human-like appearance and a chat function increased the social acceptance of elderly people toward such robots [4].

Even though various robot systems have been developed to support seniors, relatively scant attention has been focused on supporting childcare, which is another essential problem caused by aging societies. Some research works have developed robot systems that directly support childcare, for example, sensor networks or wearable sensors that recognize children's behaviours in kindergarten environments and support the paperwork of childcare workers [5] [6]. Fink et al. created and investigated the effectiveness of a robotic toy box that motivates young children to pick up their things [7]. Abe et al. developed a telepresence robot for interaction between seniors and babies/toddlers [8].

These research works developed robot systems that can also be used to support childcare. However, they did not focus on the social acceptance of their systems. We believe that the issue of such social acceptance is essential for their integration in the real world, similar to elderly-care support robot systems. In this research work, we developed scales to investigate the social acceptance of childcare support robot systems, because it is difficult to apply the knowledge and measurements of social acceptance from elderly-care support robot systems to childcare support robot systems since they have different characteristics and requirements. We must also investigate the cultural differences of the social acceptance of childcare support robot systems. Although several research works have already conducted cross-cultural surveys about attitudes toward robots [9, 10], they mainly focused on adult participants. Culture is strongly related to childcare attitudes [11]. For example, according to a survey by the International Labour Organization, USA is the only developed country that doesn't guarantee paid maternity leave. Taking paternity leave is also difficult in Japan [11].

The main contribution of this paper is its investigation of the social acceptance of two countries (Japan and USA) by developing scales to measure the social acceptance of a childcare support robot system, which was designed based on childcare worker opinions (Fig. 1). An extra trial investigated how people who experienced the childcare robot system evaluated it using our developed scales.

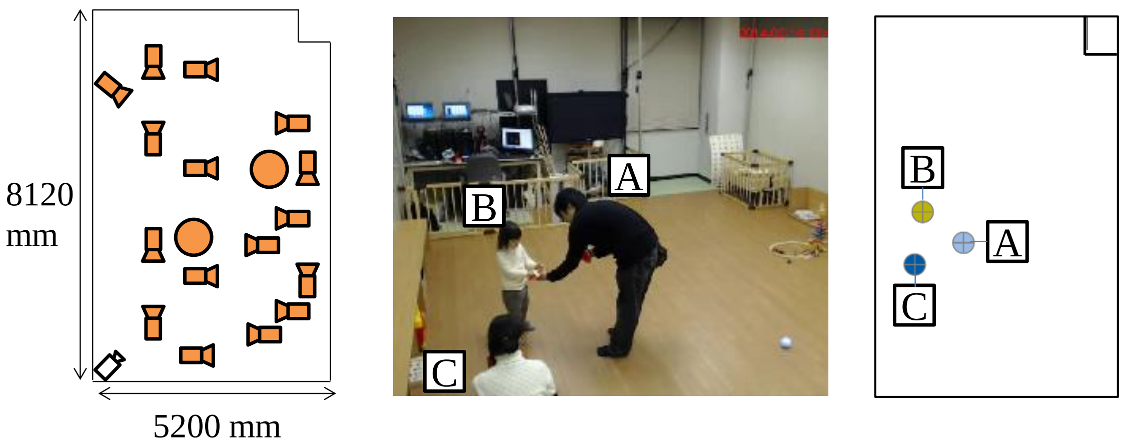


Fig. 1 Prototype of intelligent playroom as a childcare support robot system

2. Design of Childcare Support System

2.1 Interviews with childcare workers at nursery schools

Before constructing our childcare support robot system, we interviewed 26 teachers at three Japanese nursery schools to investigate what kinds of childcare support they wanted. In the sessions at different nursery schools, one male interviewer, a qualified childcare worker, interviewed three groups of seven, nine, and ten female teachers. We conducted group interviews due to time constraints since conducting individual interviews with each teacher was difficult.

Before the interviews, we explained the purpose of this research, and showed three videos from our past research works: a humanoid robot interacts with younger children at a train station such as a chat and free-play interaction [12], our people-tracking system using environmental sensors which tracks pedestrians including younger children at a shopping mall [13], and an integration system between an acceleration sensor and the tracing system to identify people in a real environments [14]. The duration of each of them was about 30 seconds. The reason of why we showed videos before interviews is to focus conversation topics during limited time period as much as possible.

In semi-structured interviews, we asked what kinds of support they wanted after the above explanations that followed the same procedure to avoid any interviewer bias. Even though sometimes conversation topics spread out because of discussions among the teachers, the interviewer tried to maintain the semi-structured interview procedure. At the end of discussion, the interviewer asked the teachers of each group to summarize their discussions about the possibilities to use technologies to support their childcare.

Through interviews and discussion, all three groups identified two types of childcare supports: helping with paperwork and entertaining children/keeping them occupied. Even though the interviewer did not share the interview results of one group with the other groups, different groups discussed the same topics and summarized them at the end of discussions. Moreover, as an additional analysis, one coder analysed and classified the transcribed interview results. In total the coder transcribed 52 conversation topics and categorized them due to their contents. As a result, there are five categories: helping with paperwork through recoding children's activities (24 topics), entertaining children/keeping them occupied (16 topics), security (2 topics), negative perspective (7 topics) and other themes (3 topics). We note that the topics in security category includes similar contents to the helping with paperwork category, because it is mainly talking about recording camera/audio information for security purpose. Therefore, we though that these two needs are obviously critical for childcare support.

The first need is helping with paperwork, including recording children's activities at nursery schools. The childcare workers are interested in sensor data that could be recorded and provided by cameras or human-tracking systems. Such information would be helpful when they record children's activities. Even if they cannot directly monitor the children when they are busy, they can confirm what the children are doing through sensor data. 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.

The next need is entertaining children and keeping them occupied. Our participating childcare workers reported that they would benefit during such hectic times as changing diapers if a system entertained children for just a few minutes. They seemed to envision robots as intelligent toys or smartphones.

As described above, we did receive several negative responses about recording children activities and using robot systems from each group; one group reported that such negative effects should be considered at the end of discussion. For example, some childcare workers expressed concerns about potential long-term ramifications. A few worried that reliance on such systems might reduce the quality of care and divert the attention of teachers away from childcare. Several expressed reservations about using such sensors and robots to record children's daily activities due to privacy concerns. However, even if a few negative comments surfaced, the childcare workers basically appeared receptive to sensors and robots for childcare in the context of providing support in nursery schools.

2.2 System overview

Based on the interview results at the nursery schools, we set two design policies for our childcare support robot system. The first supports office work, especially recording and indexing children's daily activities at nursery schools. Even if complete autonomous indexing of such daily activities is difficult because of the limitations of current technologies, indexing part (and recording most) of the data will support such paperwork responsibilities. The second supports the entertaining of children through robots. When childcare workers are busy, it would be helpful to attract children to the robot even for just a few minutes, e.g., when changing diapers.

Based on these considerations, we built a prototype of an intelligent playroom (Fig. 1) that is about 40 m^2, which is big enough to accommodate over five adults and five children. We attached environmental depth sensors to the ceiling and used a human-tracking algorithm with them [13]. Our tracking system monitors the position of all the people in the area at 20 Hz with an accuracy of approx. 30 cm. This system has robustness toward illumination changes and the colors of clothing because it uses depth information, which is useful for real environments where the sun shines. Since depth cameras see from top to down, they are also robust for crowded situations. For this system, we installed 16 depth sensors (1 Kinect V2 (Microsoft), 13 Xtions (ASUS), and a 2D-Imager (Panasonic)). We also installed two microphone arrays (16 microphones) and two USB cameras to record the sounds/videos of the children and the parents in the room (Fig. 2). Since our system remains under development, it only records the positions, the videos, and the sounds; indexing children activities is future work.

We also installed a ball-type toy robot named Sphero (http://www.sphero.com/sphero) or a tank-type toy robot named Romo (http://www.romotive.com/) to investigate how children interacted with them (Fig. 3). The robots were teleoperated in pre-defined behaviours, i.e., the Wizard of Oz style [15]. We defined the behaviours to tempt children to chase the robot, which eluded them. Thus the robot briefly distracted the children.

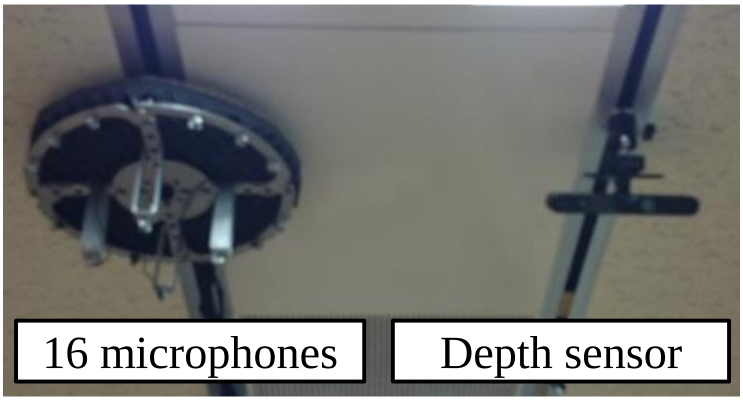


Fig 2 Microphone array and a depth sensor on ceiling

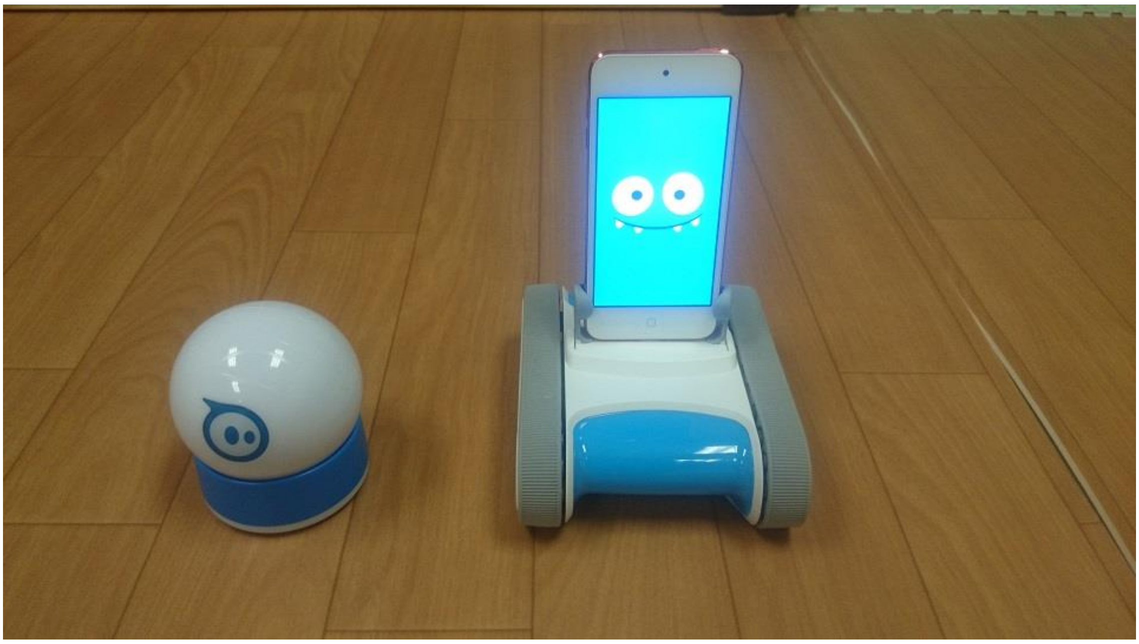


Fig. 3 Sphero and Romo from our experiments

3. Experiment: Web-Based Evaluation

In this section, we describe an experiment with a web-based survey to understand the perceptions of people from two different countries of a robot system that provides childcare support. We also evaluate the reliability of our developed scales that measure the social acceptance.

3.1 Hypothesis and predictions

Even though social robots are spreading worldwide, childcare support robotics technology is still being developed and remains relatively unknown for ordinary people. Such new concepts or technologies basically suffer from much lower social acceptance than such current technologies as processed baby food or baby formula, both of which are now commonly used in developed countries. However, when these new technologies were first introduced, their social acceptance was much lower. Since most people have little or no experience using such new technologies, they cannot imagine whether they are safe and/or beneficial, and this “ignorance” restricts social acceptance from the beginning of their introduction. In childcare, using such technologies might be perceived as irresponsible.

Based on these considerations, we expect people to have low social acceptance of childcare support robot systems because they are relatively uncommon and have never been used. Even though our hypothesis assumes negative results for current childcare support robot systems, investigating such impressions is crucial to understanding their current situations. 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.

We also speculated on culture differences, because attitudes toward childcare differ among countries. For example, Japanese people are much less likely to leave their children with babysitters, a custom that is ubiquitous in American [16] [17] [18]. Barratt et al. reported that Japanese infants only receive about two hours per week of nonmaternal care, but American infants receive about 23 hours [19]. Shwalb et al. described Japanese nonmaternal child care by considering cross-cultural differences [20]. Caudill also reported different maternal attitudes about babies [21] [22]. Since a typical American mother considers her baby a separate and autonomous being, her goal is to help her baby learn how to actively express his needs and/or wishes. On the other hand, a typical Japanese mother considers her baby an extension of herself and believes that she knows what is best for him/her [21]. Caudill et al. and Otaki et al. also reported that Japanese mothers spend more time with or in the presence of their babies than American mothers, due to the differences of their life style such as working time of Japanese fathers [22] [23]. Such differences toward babysitting might influence the social acceptance of childcare support robot systems or other childcare support technologies.

Moreover, American people had more positive social acceptances toward both information and communication technologies in education context [24] and a medical technology in childbirth context [25], compared to Japanese people; we note that in both studies the participants included parent-generation. We thought these differences of attitudes to technologies in childcare/education contexts probably reduce social acceptance of Japanese toward childcare support technologies more than in Americans. Therefore, we made the following hypothesis:

Prediction 2: Americans will have higher social acceptance for childcare support technologies than Japanese people.

3.2 Participants

In this experiment, we contracted with an online survey company in Japan to collect responses. Its participant pool (approximately 2 million people) was filtered and categorized into four categories: licensed Japanese childcare workers and Japanese parents with preschool children as well as their American counterparts. The inclusion criteria for the licensed childcare workers stipulated that they were currently working as a childcare worker. The inclusion criteria for the parents stipulated that they were currently living with children up to six years old.

Our survey included 200 Japanese people (100 licensed female childcare workers for nursery schools and 50 female and 50 male parents with preschool children), and 200 Americans (100 licensed female childcare workers and 50 females and 50 males with preschool children). The participants were recruited by e-mail to join a web survey. The number of samples was controlled to include identical ratios of mothers and fathers, but since the ratio of registered male childcare workers was too small, we only included female childcare workers and paid them approximately 500 yen (about $5.00) for their participation.

3.3 Procedure

In our survey, the participants answered questionnaires about three kinds of childcare support technologies: anesthesia during labor, baby food, and childcare support robot systems.

We chose anesthesia during labor as a candidate for two main reasons: during labor both participants (parents and childcare specialists) in Japan and America are familiar with it, and during labor it tangentially supports childcare, even though it is literally a support for childbirth. Concerning the first reason, in America, 61.0% of mothers received epidural or spinal anesthesia during labor at 2008 [26], suggesting that it is a well-known technology. Even though our participants did not have children, they are obviously potential parents, and therefore we believe they have knowledge about a common childbirth support. Also in Japan, qualified childcare workers work not only at kindergarten/nursery schools but also at midwifery homes that support childbirth. Examinations of qualified childcare licenses include several childbirth topics, which are not directly related to anesthesia during labor. Studying such information provides knowledge about childbirth for childcare workers. In fact, all of the childcare workers in the interviews were familiar with anesthesia during labor, even though they had not experienced it.

For the second reason, decreasing pain during childbirth contributes to childcare by maximizing maternal comfort and mobility after it. Moreover, acute pain during childbirth has been linked to postpartum depression [27]. Therefore, even though anesthesia during labor is for childbirth, we believe it is also related to childcare.

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 illustrations and texts to explain our two concepts because the participants are less familiar with our system than anesthesia during labor and baby food. The maximum answer time for all the questionnaire items was 20 minutes. We counterbalanced the order of the items to avoid order effects among the conditions.

3.4 Measurements

In our survey, based on our past research work, we prepared four scales to investigate the social acceptance of childcare support technologies [1]: *intention to use, safety and trustworthiness*, *negative attitudes*, and *decreasing workload*. We prepared different kinds of childcare support technologies and added a short description to each questionnaire aspect, depending on the technologies: "if you or your partner have a baby" or "if you or your partner become parents." Each item was rated on a 1 to 7 scale, where 7 is the most positive. The details of each scale are described as follows.

3.4.1 Intention to use

For this measurement, we adapted all three items from Heerink et al. [28] including, "I'm planning to use baby food in the next few days." We measured intention to use because this scale is modeled and indicates social acceptance, as shown in studies of the acceptance of new technologies [29] and social robots [30] [31]. Note that X changes depending on the following conditions: anesthesia during labor, baby food, or a childcare support robot system.

- I think that I'll use X (or suggest that my partner use it) if I have a baby in the future (anesthesia during labor) or if I'm going to raise a child in the near future (baby food, or a childcare support robot system).
- If I have a baby (anesthesia during labor) or if I'm going to raise a child (baby food, or a childcare support robot system), I'll definitely use X.

- If I have a baby (anesthesia during labor) or if I raise a child (baby food or a childcare support robot system), I plan to use X.

3.4.2 Safety and trustworthiness

A technology's safety and trustworthiness are essential factors. For example, parents believe baby food is healthy and safe; such feelings are crucial to disseminate a technology throughout the world. Therefore, we constructed a scale to investigate the safety and trustworthiness of our childcare support technologies by three distinct items: trustworthiness, cleanness/safety, and anxiety.

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

3.4.3 Negative attitudes

Subjective self-images of childcare are another essential factor that people must address to decide whether to use childcare support technologies. For example, if parents feel that using them creates a gap with their personal self-images toward childcare or if they are concerned how their friends or family could react, they might avoid such technologies. Therefore, we measured their feelings about whether using new technology creates disparities from their own self-images about childcare by constructing a scale of five distinct items. We avoided discussions about the merits of specific self-images because that debate depends on too many factors; we just want to determine how people feel about childcare support technologies. Unlike other scales, a higher value on this scale indicates negative attitudes about a technology because of the differences from self-images:

- If I am a parent, avoiding X is quite natural.
- Using X negatively affects parents.
- Since I believe 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 seriousness during childbirth or parenting increases affection for children, X should not be used.
- Using X will create negative impressions in others.

3.4.4 Decreasing workload

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

- Using X decreases 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 benefits children.
- Since X is convenient, it will decrease my childbirth or parenting load.

3.4.5 Reliability of measurements

Even though the reliability of each measurement has already been tested by our past research [1], we re-tested the reliabilities through two web-based survey. Table 1 shows the Cronbach's alpha statistics of each measurement, all of which are within a solid range in both surveys. Since such scales are generally considered reliable if Cronbach's alpha exceeds 0.70, we believe that our measurements are all reliable.

Table 1 Cronbach's alpha from web-based survey

		Intention to use	Safety and trustworthiness	Negative attitude	Decreasing workload
Japan	Anesthesia during labor	0.956	0.82	0.909	0.832
	Baby food	0.935	0.799	0.923	0.907
	Robot	0.971	0.844	0.917	0.894
USA	Anesthesia during labor	0.976	0.852	0.837	0.854
	Baby food	0.971	0.75	0.8886	0.866
	Robot	0.97	0.905	0.783	0.892
Average		0.963	0.828	0.876	0.874

3.5 Results

3.5.1 Verification of hypothesis

We conducted a three-factor mixed ANOVA for each scale on the three technologies (anesthesia during labor, baby food, and robots), countries (USA/Japan), and participant types (childcare workers, fathers, and mothers).

For intention to use (Table 2), the following main effects were significant: technologies, $F(2, 788) = 139.286$, $p < .001$, $\eta 2 = .261$, countries, $F(1, 394) = 35.114$, $p < .001$, $\eta 2 = .082$, and participant types, $F(2, 788) = 11.290$, $p < .001$, $\eta 2 = .054$. The two-way interaction effects were also significant among technologies, countries, and participant types, $F(4, 1576) = 3{,}494$, $p = .008$, $\eta 2 = .017$. The simple interaction effects were also significant between technologies and countries, $F(2, 788) = 15.472$, $p <.001$, $\eta 2 = 0.038$, and technologies and participant types, $F(2, 788) = 5.137$, $p < .001$, $\eta 2 = 0.025$.

The simple-simple main effect of countries was significant in anesthesia during labor and childcare workers ($p = .001$), baby food and childcare workers ($p < .001$), baby food and fathers ($p = .026$), baby food and fathers ($p < .001$), and anesthesia during labor and mothers ($p < .001$).

The simple-simple main effect of participant types was significant in robots and USA (fathers > childcare workers: $p < .001$, mothers > childcare workers: $p < .001$) and baby food and Japan (mothers > childcare workers: $p = 0.23$).

The simple-simple main effect of technologies was significant in childcare workers and USA (baby food > anesthesia during labor: $p < .001$, baby food > robots: $p < .001$, and anesthesia during labor > robots: $p < .001$), fathers and USA (baby food > robots: $p < .001$, and anesthesia during labor > robots: $p < .001$), mothers and USA (baby food > robots: $p < .001$, and anesthesia during labor > robots: $p < .001$), childcare workers and Japan (baby food > anesthesia during labor: $p < .001$, baby food > robots: $p < .001$, and anesthesia during labor > robots: $p = .008$), and mothers and Japan (baby food > anesthesia during labor: $p < .001$, and baby food > robots: $p < .001$),

Table 2 Average and standard deviation of intention to use

	USA			Japan		
	Childcare workers	Male parents	Female parents	Childcare workers	Male parents	Female parents
Anesthesia during labor	4 (2.15)	4.55 (1.75)	4.75 (1.97)	3.09 (1.57)	3.73 (1.64)	3.09 (1.74)
Baby food	5.16 (1.55)	5.23 (1.61)	5.21 (1.69)	3.99 (1.50)	3.98 (1.40)	4.72 (1.86)
Robot	2.16 (1.52)	3.33 (1.48)	3.17 (1.67)	2.46 (1.44)	3.61 (1.13)	2.56 (1.64)

For safety and trustworthiness (Table 3), the following main effects were significant: technologies, $F(2, 788) = 108.829$, $p < .001$, $\eta2 = .216$, and participant types, $F(2, 788) = 11.298$, $p < .001$, $\eta2 = .054$. The two-way interaction effects were significant among technologies, countries, and participant types, $F(4, 1576) = 2.609$, $p = .034$, $\eta2 = .013$. The simple interaction effects were also significant between technologies and countries, $F(2, 788) = 11.311$, $p < .001$, $\eta2 = 0.028$, and technologies and participant types, $F(2, 788) = 3.257$, $p = .012$, $\eta2 = 0.016$.

The simple-simple main effect of countries was significant in robots and childcare workers ($p = .004$), anesthesia during labor and fathers ($p = .020$), baby food and fathers ($p = .026$), and anesthesia during labor and mothers ($p = .005$).

The simple-simple main effect of participant types was significant in anesthesia during labor and USA (fathers > childcare workers: $p = .018$, mothers > childcare workers: $p = .017$), baby food and USA (fathers > childcare workers: $p = .016$), robots and USA (fathers > childcare workers: $p < .001$, mothers > childcare workers: $p < .001$), robots and Japan (fathers > childcare workers: $p = .002$).

The simple-simple main effect of the technologies was significant in childcare workers and USA (baby food > robots: $p < .001$, and anesthesia during labor > robots: $p < .001$), fathers and USA (baby food > robots: $p < .001$, and anesthesia during labor > robots: $p <.001$), mothers and USA (baby food > robots: $p < .001$, and anesthesia during labor > robots: p < .001), childcare workers and Japan (baby food > robots: $p < .001$, and anesthesia during labor > robots: $p = .008$), and mothers and Japan (baby food > anesthesia during labor: $p = .004$, baby food > robots: p < .001, and anesthesia during labor > robots: $p = .016$).

Table 3 Average and standard deviation of safety and trustworthiness

	USA			Japan		
	Childcare workers	Male parents	Female parents	Childcare workers	Male parents	Female parents
Anesthesia during labor	3.75 (1.56)	4.39 (1.25)	4.39 (1.45)	3.63 (1.21)	3.76 (1.13)	3.63 (1.24)
Baby food	3.88 (1.10)	4.44 (1.17)	4.07 (1.38)	3.96 (1.04)	3.93 (0.82)	4.27 (1.46)
Robot	2.32 (1.31)	3.29 (1.15)	3.19 (1.46)	2.84 (1.28)	3.60 (0.92)	3.02 (1.32)

For negative attitudes (Table 4), the following main effects were significant: technologies, $F(2, 788) = 81.289$, $p < .001$, $\eta 2 = .171$, countries, $F(1, 394) = 18.655$, $p < .001$, $\eta 2 = .045$, and participant types, $F(2, 788) = 7.117$, $p = .001$, $\eta 2 = .035$. The simple interaction effect was also significant between technologies and participant types, $F(4, 1576) = 8.749$, $p <.001$, $\eta 2 = 0.012$).

The simple main effect of the participant types was significant in anesthesia during labor (childcare worker > mothers: $p = .010$, fathers > mothers: $p = .002$) and robots (childcare workers > fathers: $p = .004$, childcare workers > mothers: $p < .001$).

The simple main effect of the technologies was significant in childcare workers (baby food > anesthesia during labor: $p < .001$, robots > anesthesia during labor: $p < .001$), fathers (baby food > anesthesia during labor: $p < .001$, robots > anesthesia during labor: $p = .018$), and mothers (baby food > anesthesia during labor: $p < .001$, baby food > robots: $p < .001$, and robots > anesthesia during labor: $p < .001$).

Table 4 Average and standard deviation of negative attitude

	USA			Japan		
	Childcare workers	Male parents	Female parents	Childcare workers	Male parents	Female parents
Anesthesia during labor	3.47 (1.12)	3.46 (1.27)	3.22 (1.22)	3.35 (1.18)	3.64 (1.17)	2.73 (1.24)

Baby food	4.54 (0.93)	4.60 (1.08)	4.49 (1.00)	4.00 (0.96)	4.06 (1.07)	4.50 (1.29)
Robot	4.65 (1.27)	4.17 (1.05)	4.02 (1.22)	4.28 (1.34)	3.76 (1.21)	3.36 (1.34)

For decreasing workload (Table 5), the following main effects were significant: technologies, $F(2, 788) = 55.633$, $p < .001$, $\eta 2 = .124$, countries, $F(1, 394) = 12.120$, $p = .001$, $\eta 2 = .030$, and participant types, $F(2, 788) = 4.808$, $p = .009$, $\eta 2 = .024$. The two-way interaction effects were also significant among technologies, countries, and participant types, $F(4, 1576) = 2.511$, $p = .041$, $\eta 2 = .013$. The simple interaction effects were significant between technologies and countries, $F(2, 788) = 5.956$, $p = .003$, $\eta 2 = 0.015$, and technologies and participant types, $F(2, 788) = 2.923$, $p = .020$, $\eta 2 = 0.015$.

The simple-simple main effect of countries was significant in anesthesia during labor and childcare workers ($p = .043$), baby food and childcare workers ($p < .001$), and baby food and mothers ($p = .001$). The simple-simple main effect of the participant types was significant in robots and USA (mothers > childcare workers: $p = .038$) baby food and Japan (mothers > fathers: $p = .007$), and robots and Japan (fathers > childcare workers: $p = .039$).

The simple-simple main effect of the technologies was significant in childcare workers and USA (baby food > robots: $p < .001$, and anesthesia during labor > robots: $p < .001$), fathers and USA (baby food > robots: $p = .033$, and anesthesia during labor > robots: $p = .007$), childcare workers and Japan (baby food > anesthesia during labor: $p < .001$, baby food > robots: $p < .001$, and anesthesia during labor > robots: $p < .001$), and mothers and Japan (baby food > anesthesia during labor: $p = .001$, baby food > robots: $p < .001$, and anesthesia during labor > robots: $p = .002$).

Table 5 Average and standard deviation of decreasing workload

	USA			Japan		
	Childcare workers	Male parents	Female parents	Childcare workers	Male parents	Female parents
Anesthesia during labor	3.85 (1.09)	4.18 (1.08)	4.17 (1.31)	4.16 (0.94)	4.15 (1.03)	4.37 (1.23)
Baby food	3.86 (1.32)	4.08 (1.33)	4.25 (1.34)	4.71 (1.08)	4.29 (0.90)	5.04 (1.35)
Robot	3.23 (1.43)	3.56 (1.13)	3.78 (1.29)	3.47 (1.24)	4.01 (0.87)	3.67 (1.32)

Here, we summarize the results from our web-survey. For intention to use in this study, American have more positive impressions than Japanese, except for anesthesia during labor with fathers and childcare support robot system with all types. Scores of childcare support robot system are more negative than anesthesia during labor and baby food, except for Japanese fathers.

For safety and trustworthiness in this study, American childcare workers have more negative impressions about the childcare support robot system than Japanese. American mothers and fathers have more positive impressions about anesthesia during labor than Japanese, and American fathers have more positive impressions about baby food than Japanese. Childcare support robot system are more negative than anesthesia during labor and baby food, except for Japanese fathers.

For negative attitude in this study, American have more negative impressions than Japanese for childcare support technologies. Attitudes for childcare support robot system are more negative than anesthesia during labor. Only Japanese mother is more negative to baby food than childcare support robot.

For decreasing workload in this study, Japanese childcare workers have more positive impressions about anesthesia during labor and baby food than American.

Japanese mothers have more positive impressions about baby food than American. Scores of childcare support robot system are more negative than anesthesia during labor and baby food, except for American mothers and Japanese fathers.

These analysis results indicate that people have lower social acceptance for a childcare support robot system than the current childcare support technologies from the viewpoints of each scale, except for the part of scales in this study. Therefore, prediction 1 was partially supported. Moreover, American have higher scores for intention to use, but more negative scores for a part of scale which is opposite from our assumptions. Therefore, prediction 2 was partially supported too.

4. Field Trial

In this section, we describe a field trial with ordinary people who experienced a prototype of our childcare robot system and investigate their perceptions and impressions. Unlike like the above survey study that compared American and Japanese reactions, this field evaluation was only conducted with Japanese participants.

4.1 Participants

To gather participants, we put leaflets in a local childcare magazine that is distributed to a small city's childcare centres. 64 people (30 parents and 34 preschool children) participated in the field trial. The participants' children were in preschool (i.e., under six years old, average: 2.13, S.D: 1.16). Note that participating parents were required to have at least one child younger than three years of age; nine participants (with toddlers) participated with older siblings who are younger than six years old. Parents were paid

4,000 yen (about $34, including transportation expenses) for two hours of participation. 30 parents (23 women and 7 men) answered questionnaires.

4.2 Procedure

In the field trial, the participants acted freely in the environment for two hours. The first hour was used to acclimatize the children to the environment, to explain the concept of our research, and to introduce the human-tracking and recording systems. Next the participants filled out informed consent forms. In the second hour, we randomly showed either robot (Sphero or Romo) and started teleoperation to investigate the interactions between children and parents. After two-hour sessions, the parents answered questionnaires, which included the developed scales. We asked them to fill out questionnaires by considering childcare for their youngest child (ignoring or downplaying the participation of older children, if applicable) because children's ages are related to attitudes toward childcare robot systems.

4.3 Measurements

In this field trial, we measured the same four scales of our experiment about a childcare support robot: *intention to use*, *safety and trustworthiness*, *negative attitudes*, and *decreasing workload*. We also interviewed the parents to identify what kinds of childcare support they wanted.

We again tested the reliability levels of each measurement in the field evaluation. The results for each fell within a good range (Table 6). Since Cronbach's alpha exceeded 0.70, we believe that our measurements are all reliable on average.

Table 6 Cronbach's alpha from field evaluation

	Intention to use	Safety and trustworthiness	Negative attitude	Decreasing workload
Robot	0.875	0.701	0.890	0.866

4.4 Results

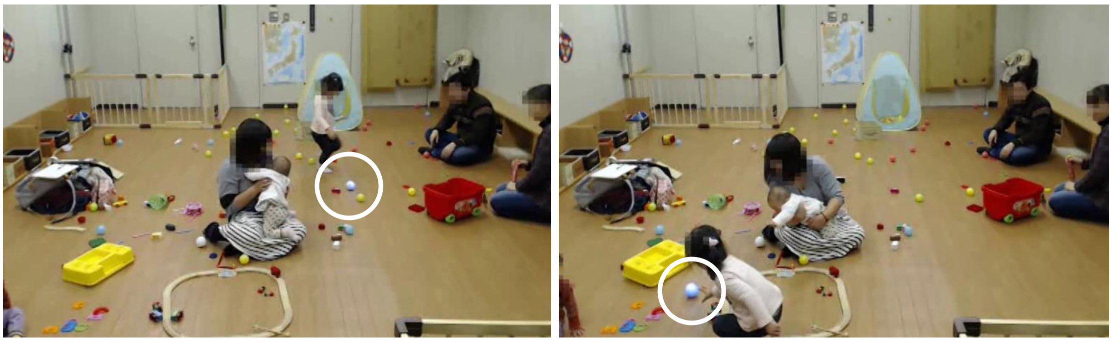
4.4.1 Observed behaviours and interview results

Both the children and parents spent the first hour in the environment, which resembled usual playrooms. The children freely played with other children and their parents or alone with toys. Parents were basically playing with their children or talking with other parents.

In the second hour, the experimenter controlled the installed robots, which entertained most of the children. For example, after a parent suggested that her daughter chase Sphero (Fig. 4-a), the girl started to chase it (Fig. 4-b). She continued her interaction with Sphero for more than 30 minutes (Fig. 4-c). Some crawling babies also tried to look at the robot or capture it (Fig. 4-d). Romo also entertained children. Some children repeatedly asked their parents questions like, "where's the robot?" when they failed to catch Romo. At the end of the trial, a few children wanted to remain in the environment, suggesting the potential success of an intelligent playroom.

(a)

(b)



(c) (d)

Fig. 4 Children interacting with Sphero

On the other hand, some children did not want to interact with either robot. Their parents thought their children might have been scared by an object darting around the floor. Even if their parents interacted with the robot, the children refused to interact with it during the trial.

After observing enough of each child's behaviors, we interviewed parents to scrutinize their attitudes about our childcare support robotics system. All of the parents positively evaluated our sensing system. They believe that such sensor data will lead to greater understanding of children activities, even though they expressed concern about the privacy risks of the recorded data.

For using a robot to train their children, they also positively evaluated the robot after observing its interactions with their children. Even if it interacted with or entertained their children for just a few minutes or more by moving around, parents could imagine scenes where they might be too busy to play with their children or to distract them. They believed that such robots could be considered intelligent toys like smartphones and have advantages over them because the robot can move around with its sensor information.

4.4.2 Questionnaire results

In our field study, we gathered questionnaire items using the same items of the first experiment. For reference, we conducted t-tests for each measurement about childcare support robots between a web-based survey (Japanese participants) and a field study (Fig. 5); even though these comparisons were not well controlled, showing differences is useful to understand how participants evaluated the system after their experiences. For intention to use, the averages were 2.78 (S.D., 1.50) and 4.50 (S.D., 1.25). We found a significant difference among the conditions ($t(228) = -5.993$, $p < .001$, $d=1.17$). For safety and trustworthiness, the averages were 3.08 (S.D., 1.25) and 4.65 (S.D., 1.13). We found a significant difference among the conditions ($t(228) = -6.58$, $p < .001$ $d=1.27$). For the negative attitudes, the averages were 3.92 (S.D., 1.35) and 2.32 (S.D., 1.02). We found a significant difference among the conditions ($t(228)=6.20$, $p < .001$ $d=1.22$). For decreasing workload, the averages were 3.66 (S.D., 1.120) and 4.91 (S.D., 1.01). We found a significant difference among the conditions ($t(228) = -5.473$, $p < .001$ $d=1.13$).

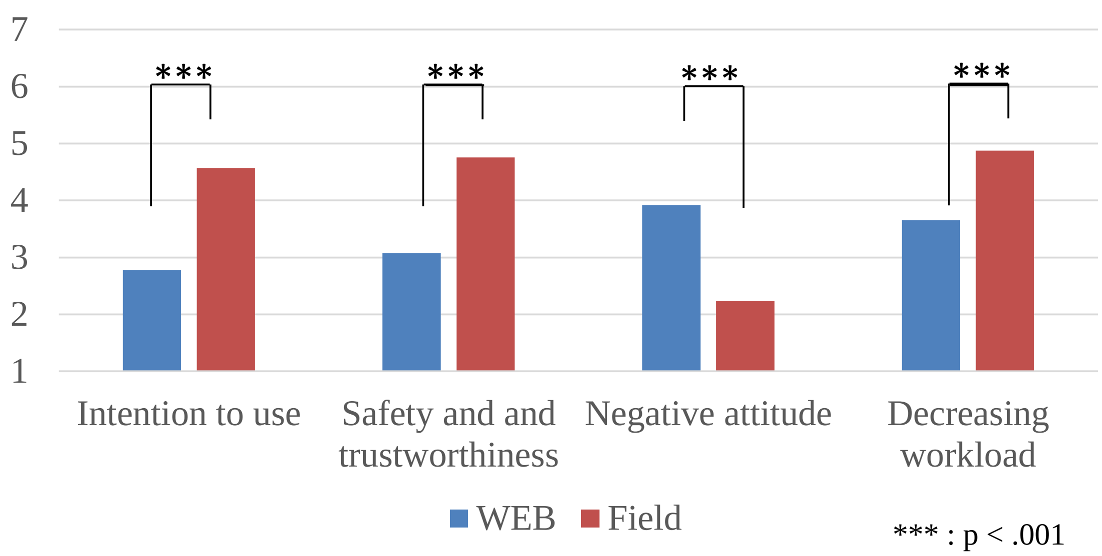


Fig. 5 Average and S.E of each scale between a web-based survey and a field study

5. Discussion

5.1 Design implication

One important contribution of this study is that we made scales to investigate the social acceptance of childcare support technologies and experimentally tested their reliability through a web-based survey with two different countries. These scales can be used to investigate cultural differences about different kinds of childcare support robots from various viewpoints, such as a telepresence robot for little children [8].

Another contribution is that we confirmed that experiencing a prototype system increases its social acceptance. Deploying an actual system in the real world is one essential approach for the social implementation of robot services. In particular, to grow the research field of childcare support robotics, the social acceptance of systems must be increased. Future work must develop more long-term field trials with our system to investigate its effectiveness.

In this research work, we used two kinds of moving robots: Sphero and Romo. Their main difference is their faces; Romo has an animated face on its display, unlike Sphero, which doesn’t have one. We assumed that Romo would be more accepted by children because of its anthropomorphic appearance, but our field study suggests that both robots are equally attractive to children in experimental environments. For just playing with a robot in the short term, a robot’s physical movement (in this research, the robot was controlled by the operator) might be more effective than its anthropomorphic appearance. Interesting future work will investigate the relationships among a robot's appearance, its movements, and the levels of boredom experienced by children.

5.2 Attitudes to anesthesia during labor and baby food between USA and Japan

In this research work, we focused on the differences between a childcare support robot system and existing childcare support technologies, i.e., anesthesia during labor and baby food. We did not deeply analyze them in the result section. In this section, we describe an interesting phenomenon of cultural differences between USA and Japan about existing childcare support technologies.

Our experimental results showed that Japan participants showed a lower intention to use baby food and anesthesia during labor than American participants; in fact, the diffusion ratios in these countries are also different [25]. On the other hand, Japan participants showed lower negative attitude about baby food and anesthesia during labor than American participants, who indicated higher negative attitudes to them than Japan participants, even though Americans are more accustomed to them. This opposite phenomenon between their higher intention to use (or the diffusion ratio) and negative attitudes has also been reported in past research [25] conducted over 20 years ago.

5.3 Limitations

This research work has several limitations. In our web-based survey, we only compared USA and Japan without involving European countries, which guarantee relatively large paid leave from work to parents [11]. Therefore, the social acceptance of childcare support robot systems by Europeans remains unknown. Since we only investigated three candidates in our web-based survey, it is also unknown how participants evaluated other topics such as babysitters, nannies, or baby-monitoring tools. Also, the United States mixed with various value and culture systems from different races or countries, therefore it was difficult to gather questionnaires uniformly by considering people's various characteristics. These limitations should be considered at interpretations of our results.

We only conducted interviews in Japan to design a childcare support system because of the difficulty of interviewing enough American teachers in Japan. Instead of interviews with American teachers, we investigated the workload of American childcare workers. A survey reported that they spend much time on both communication with children and office work (such as documentation) [32]. This suggests that supports for both tasks will also help American teachers, as in the Japanese case. In other words, even though we did not interview American childcare teachers for designing our childcare support robot system, the psychological impact of the supports would probably be similar for both countries because both childcare workers felt similar workloads. Also, since other childcare support technologies (anesthesia during labor and baby food) are common between U.S and Japan, their psychological impact would probably be similar, too.

In our field study, we failed to adequately control the ages of the participants and the existence of siblings. Even an age difference of just a few months or the presence of siblings might hugely affect their interaction with a teleoperated robot. For instance, if a child is scared/intimidated by robots, her parents will probably have negative impressions of the robots that caused low social acceptance. Our robots were controlled by an operator during the field study; a completely autonomous robot might change parental feelings. Moreover, the field study was conducted at one location, but people's attitudes could change depending on experimental locations.

In the comparison of a web-based survey and a field study, we didn’t control the number of participants and their background knowledge very well. We also only conducted our field study in Japan, and these differences limit the interpretations of our experimental results. For example, for a web-based survey, video stimuli would provide knowledge about childcare support robotics. Positive bias in the field study might also exist because people without positive feelings for childcare support robotics might have low motivation to participate in our experiment.

6. Conclusion

This paper investigated the social acceptance of people toward a childcare support robot system from various viewpoints by comparing current childcare support technologies through a web-based survey and a field study. We developed scales to investigate the essential factors related to using childcare support technologies from three perspectives: safety and trustworthiness, negative attitudes, and decreasing workload. We first conducted a web-based survey to investigate the social acceptance of both American and Japan people toward childcare support technologies. Our experimental results indicate that the people of both countries showed lower social acceptance toward childcare support robotics than current childcare support technologies (baby food and anesthesia during labor), except for a part of combination with participant types. In our study, Americans might have higher intention to use toward childcare support technologies than Japan people, but other scales were lower rated than Japan people. Additionally, we conducted a field study to investigate whether the experiences of a childcare support robot system provide positive impressions to users.

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