

DESIGN GUIDELINES FOR CHILDCARE ROBOTS WITH AN ETHNOGRAPHIC STUDY OF DUAL INCOME AND SINGLE INCOME FAMILIES

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ABSTRACT:

As childcare has become a serious social concern in Korea, the development of a childcare robot is of great interest. In particular, with the increase of dual-income families, designing childcare robots for respective dual and single income households is needed. This paper presents an ethnographic study of dual and single income families with a child to develop design guidelines for childcare robots for those respective groups. We use in-depth interviews, home tours and a one-week journal written by mothers to gather the requirements during interaction between mother and child, and user and product. A total of 6 primary requirements and each with their respective secondary requirements were gathered. By analyzing the frequency of the primary and secondary requirements we were able to find both similarities and differences between dual and single income households. By quantifying the importance of robot design issues based on frequency of

primary requirements weighted by degree of correlation between requirements and issues, we present design guidelines for childcare robots for dual and single income families.

1. INTRODUCTION

The development of robotics has led to the increase in robots in our daily lives. Therefore the need for natural interaction between human and robot has become increasingly important; in order to achieve natural interaction a study to define a robot's role and function based on the analysis of the users' lifestyles is required. In a previous ethnographic study for the analysis of robot users' lifestyles, Forlizzi et al. analyzed an ecology of elders living independently in their homes, and proposed design guidelines for robots which would assist elders living alone (Forlizzi, DiSalvo, Gemperle, 2004). In addition, Forlizzi studied the social effects of robots introduced to households, by studying the changes in users' ecology with the introduction of cleaning robots (Forlizzi, 2007).

Of the various applications for robots the need for childcare robots is becoming more important (Choi, 2005). Previous works on childcare robots include the study on the scenarios and design process of childcare robot, PaPeRo (Osada, Ohnaka, Sato, 2006), a childcare robot which assists in communication between children and parents at a nursery school (Oonaka, 2005), a robot (Robovie) to help teach English to children (Kanda, Hirano, Eaton, Ishiguro, 2004), and even robots designed to treat and educate autistic children (Robins, Dautenhahn, Te Boekhorst, Billard, 2006). According to the Korean Statistical Information System, childcare is the major factor (29.3%) behind female unemployment (The Korean Statistical Information System, 1998). It follows that childcare issues are becoming a major social issue and therefore the design of a childcare robot is of great interest. In particular the percentage of dual-income households is increasing (Song, 2006), leading to the need to investigate the differences from single-income household in designing childcare robots. The goal of this study was to use ethnographic studies of single and dual income households with a child to develop design guidelines for childcare robots by comparing the differences and similarities between those respective groups.

2. ETHNOGRAPHY OF SINGLE AND DOUBLE INCOME FAMILIES

2. 1. SUBJECTS

Subjects for this study were 5 single-income and 5 double-income families with a child between the ages of 4 to 7. The subjects were chosen as follows: First, in order to abstract the major concern behind female unemployment, families raising a child were chosen. Second, following the rapid increase in the number of dual-income families, comparisons between single and dual income were needed. Third, children between the ages of 4 and 7 possess nearly adult capacity to utilize tools (Kim, Jeong, 2003), but also in contrast they are more positive towards robots when compared to adults and therefore may become the primary robot users(Scopelliti, Giuliani, D'Amico, Fornara, 2006). Subjects were enrolled through advertisements in the Daejeon area. The average age of the participants of the ethnographic study were similar for both mothers (Dual-income: 35.5%, Single-income: 35%) and children (Dual-income: 5%, Single-income: 5.5%). Also the education levels of the mothers were also equal as college graduates. However, an average expenditure towards education was 1.7 times greater at US\$600 for dual-income families, while only being US\$360 for single-income families. In addition, the average time per day spent with children was 4 hours from 6 PM after work to 10 PM for dual-income families, whereas it was 7 hours from 3 PM after school to 10 PM for single-income families.

2. 2. DATA SOURCES

Data was gathered in three ways: in-depth interviews of mothers, home tours, and by childcare journals. The in-depth interviews were used to determine personal data for the mothers, fundamental information on rearing a child including average expenditures for childcare purposes and educational facilities, and typical child-related workday and weekend activities for single and dual income families. After the interviews home tours were used to observe and document childcare related products and environments by photographing. Childcare journals were recorded by each family for one week. By referencing the lifestyle by time data provided by the Korean Statistical Information System(The Korean Statistical Information System, 2004), we were able to determine the 5 most time consuming activities as: childcare, media utilization, moving time, preparation and cleanup of food, and eating and snacking. Participants recorded the 5 primary activities as well as one extra activity everyday, and described their satisfaction level and reasons with that activity as well as any products used and their satisfaction with that product during that activity.

2. 3. DATA ANALYSIS

Analysis of the data was done with a focus on the interactions between mother and child, and user and product for both single and dual income families. For each interaction primary and secondary requirements of single and dual income households were organized and their frequency was analyzed.

3. FINDINGS

The requirements of single and dual income families abstracted through the ethnographic study are divided into primary and secondary. The 6 primary requirements of “Scheduling, Education, Communication, Emotional Response, Monitoring, and Entertainment,” and the secondary requirements were extracted.

3. 1. FREQUENCY OF PRIMARY REQUIREMENTS

The order of importance represented by the frequency of primary requirements is as follows for dual-income households: Scheduling(30.6%)-Communication(19.1%)-Monitoring(15.9%)-Emotional Response(15.3%)-Education(13.4%)-Entertainment(5.7%), for single-income households it was: Education(35.9%)-Emotional Response(19.5%)-Scheduling(15.9%)-Monitoring(14.8%)-Communication(9.4%)-Entertainment(4.5%) (Fig. 1). So for dual-income households, the need for Scheduling due to restrictions in time was apparent while the needs for Education were relatively low. However in single-income households Education appears as the most important concern. Also, for dual-income families the requirement for Communication exceeds that of Emotional Response while for single-income families it is the other way around.

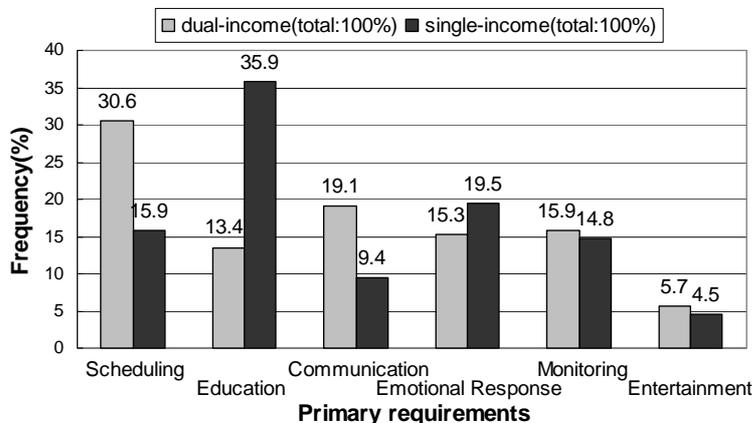


Figure 1: Primary requirements of dual and single income households.

Next the frequency of the primary requirements for single and dual income households was compared. Dual-income families showed 2 times as much Communication, 1.9 times as much Scheduling and 1.3 times as much Entertainment requirements in comparison to single-income families. On the other hand single-income families displayed 2.7 times as much Education and 1.3 times as much Emotional Response requirements over dual-income families. Monitoring requirements were similar for both types of households. The large differences in frequency for the requirements of single and dual income families indicate a need for differentiation in design of childcare robots for each of these families.

3. 2. FREQUENCY OF SECONDARY REQUIREMENTS

The analyses of the frequency of secondary requirements were as follows.

Scheduling: For both types of households 'Lack of time due to assisting children (Dual: 21.7%, Single: 15.9%)' was the most cited requirement (A in Fig. 2). For dual-income families in addition to 'Lack of time due to assisting children', 'Conflicts in schedules between mother and child(5.7%), Handling of unexpected situations(2.6%), Difficulty of managing schedules for child's private education(0.6%)' were such that the primary requirement of Scheduling for dual-income households(30.6%) was 1.9 times that of single-income households(15.9%) (Fig. 2).

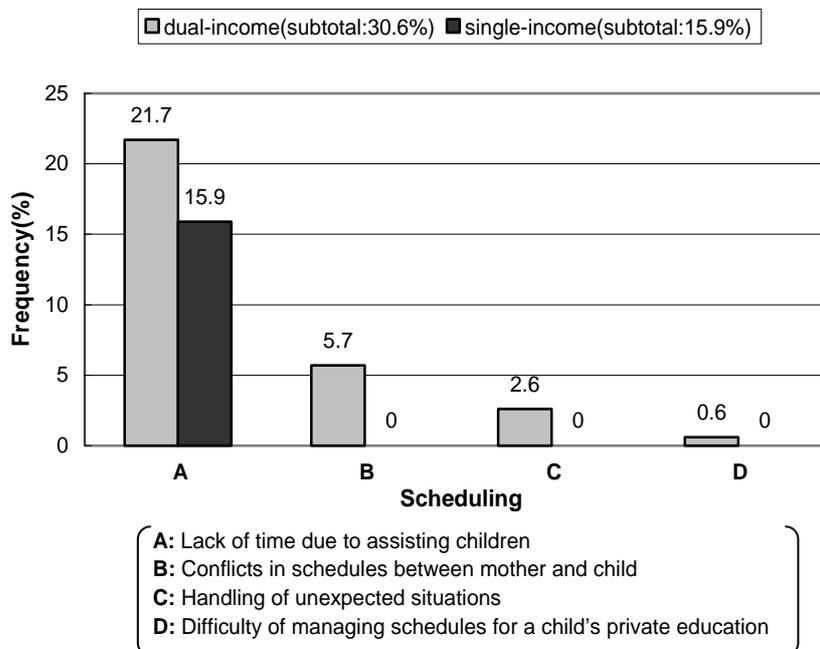


Figure 2: Secondary requirements of Scheduling of dual and single income households.

Education: For all secondary requirements in Education single-income households showed higher frequency than dual-income ones (Fig. 3). Both types of households chose 'Effective use of various mediums for education (Dual: 7.0%, Single: 9.7%)' with the highest frequency (A in Fig. 3). However dual-income families displayed the second highest frequency towards 'Education through appropriate positive reinforcement (3.2%)' and the lowest for 'Education through experience (1.3%)', while single-income families showed the second highest preference for 'Education through experience (9.0%)' and the lowest preference for 'Education through appropriate positive reinforcement (4.0%)' (B & D in Fig. 3). This is due to difficulty in educating children through first hand experience from time constraints put on dual-income families, thus leading to efficient education through positive reinforcement. In contrast single-income families have the extra time to spend teaching effectively through experiences and we see that the preferred method of education for them is not through spontaneous positive and negative reinforcement.

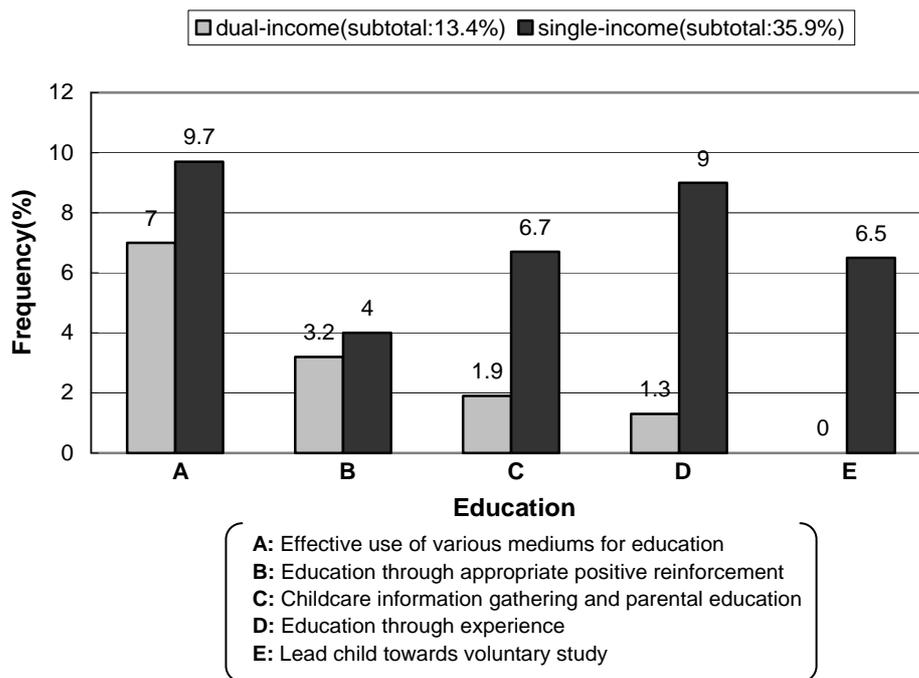


Figure 3: Secondary requirements of Education of dual and single income households.

Emotional Response: While 'The importance of sharing time and space between household members (11.5%)' had the highest frequency for dual-income families, single-income families gave the same category(4.9%) the lowest frequency while showing preference towards 'Displays of affections through various mediums (8.8%)' as the most cited secondary requirement(Fig. 4). This is due to the lack of time to spend with children for dual-income families which leads to the

high requirements for 'The importance of sharing time and space between household members', while for single-income families who have a greater excess of time show increased frequency towards 'Displays of affections through various mediums'.

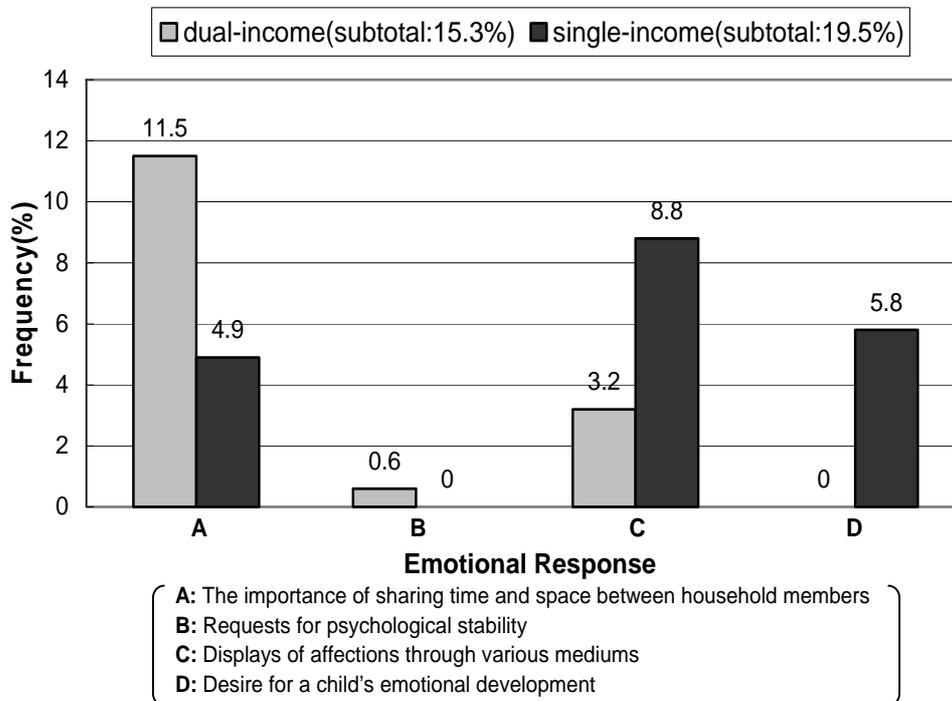


Figure 4: Secondary requirements of Emotional Response of dual and single income households.

Monitoring: Dual-income families chose 'Removal of harmful contents (7.0%)' with the highest frequency, while the single-income families chose this category (0.5%) as the lowest (A in Fig. 5). For families without much time to spend with children the fear of exposure towards harmful contents was high, while families with more amounts of time to spend with children had a relatively low need for restriction of harmful contents. Instead single-income households chose 'Dietary health management (Single: 8.5%, Dual: 2.6%)' with the highest frequency (C in Fig. 5). This shows that single-income households are more sensitive towards the diets of their children than dual-income households.

Entertainment: Both types of households did not show a high frequency count for Entertainment (Fig. 6). Comparisons within the category show that both chose 'Need for play partner (Dual: 5%, Single: 4.0%)' with the highest frequency and 'Satisfaction of possession (Dual: 1.9%, Single: 0.5%)' with the next highest frequency.

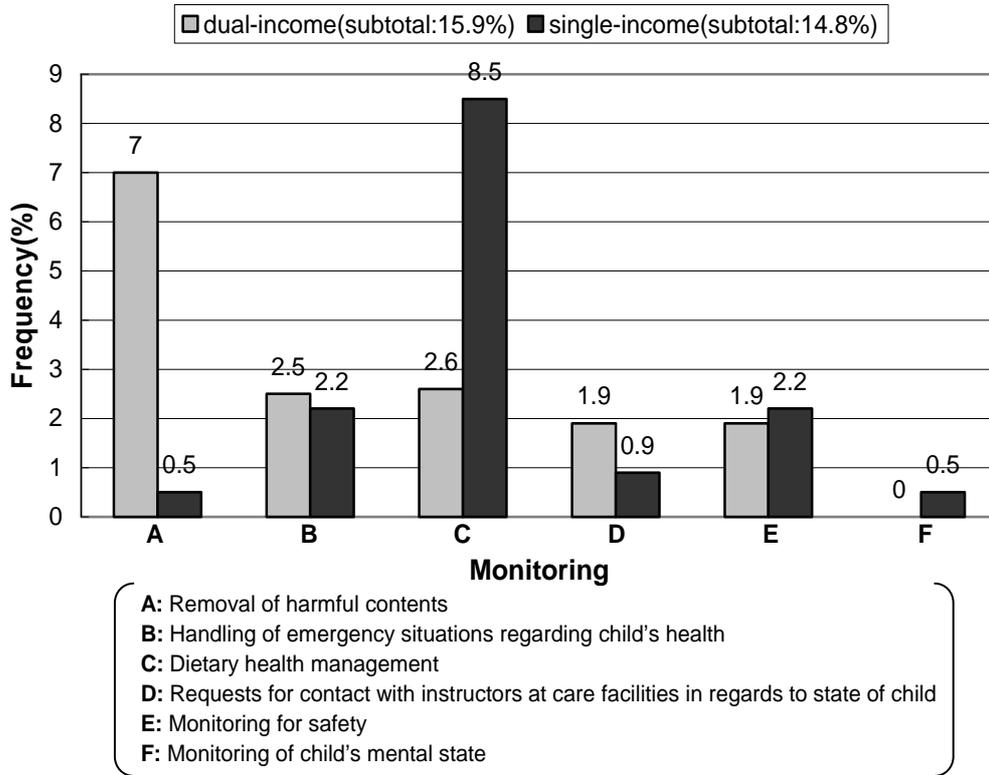


Figure 5: Secondary requirements of Monitoring of dual and single income households.

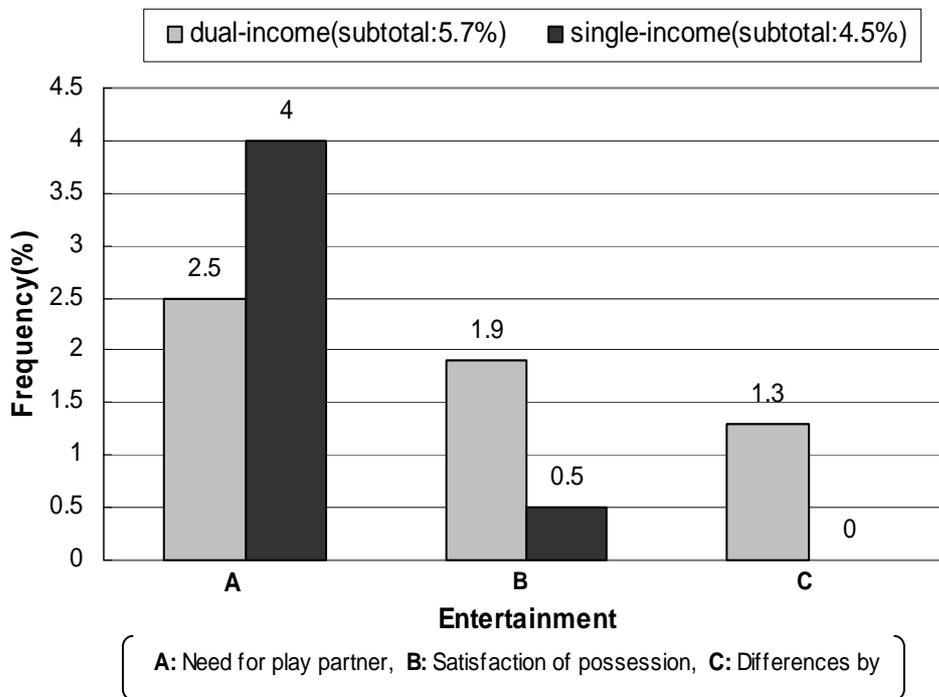


Figure 6: Secondary requirements of Entertainment of dual and single income households.

4. DESIGN GUIDELINES FOR CHILDCARE ROBOTS

Using the analysis of requirements for dual and single income households in conjunction with the robot design issue provisions proposed by Breazeal(2004), we suggest the main robot design issues for childcare robots.

4. 1. DESIGN ISSUES FOR CHILDCARE ROBOTS

Breazeal(2004) proposed the following 9 issues to be considered for Human-Computer Interaction(HCI) applied to Social Robots.

- *Comparative Media Issue*: The effects of all various sensory mediums provided by the robot. Issues regarding similarities and differences between the robot's media and previous HCI media with respect to interaction.
- *Naturalness Issue*: Issues of natural interaction with the robot. Consideration towards the human-like design or another design for natural interaction with the robot.
- *User Expectation Issue*: Issue of expectation of the robot's level of capabilities and interaction methods by the user. Consideration for the prevention of disappointment and frustration of the user.
- *Quality Issue*: Issue of increasing the quality of life by utilizing the robot. Consideration of the enjoyment, usefulness, and values brought about by the robot.
- *Relationship Issue*: Issue of social relationship between human and robot. Consideration towards if the robot will be accepted as a tool, a pet, or as a person.
- *Teamwork Issue*: Issue of effective teamwork between human and robot. Consideration of effective means of communications to maximize the robot's abilities.
- *Personality Issue*: Issue of the impact of the user's personality on the design of the robot and whether or not to give the robot its own personality. Consideration for the type and the level of personalities to grant to the robot.

- *Cultural Issue*: Issue of the effects of culture on robot design. Consideration for the communicative styles, gestures, and manners utilized by the robot with regard to cultures.
- *Acceptance Issue*: The issue of how humans will socially accept robots (with favor vs with skepticism). Consideration for general principles the robot must follow to become socially acceptable.

Each issue describes the primary methods in which a social robot should differ from a computer or other digital products. By combining the primary requirements of single and dual income families described in the previous chapter 3 with the 9 issues proposed by Breazeal into a matrix, we can understand the relationship between the requirements and issues. The number of circles (between 0~4) represents the degree of correlation between primary requirements and robot design issues (Table 1).

Table 1: The correlation between primary requirements and robot design issues.

| | Emotional Response | Entertainment | Communication | Education | Monitoring | Scheduling |
|-------------------|--------------------|---------------|---------------|-----------|------------|------------|
| Quality | OOO | OO | OOO | OOO | OOO | OOO |
| Comparative Media | OOO | OOO | OOO | OOO | OOO | O |
| Teamwork | OO | OOO | O | OO | OOO | OOO |
| User Expectation | OOO | OOO | OOO | OOO | OO | - |
| Naturalness | OOO | OOO | OOO | OO | - | - |
| Personality | OOO | OOO | OO | OO | - | - |
| Relationship | OOO | OOO | O | OO | - | - |
| Cultural | OOO | OOO | OO | O | - | - |
| Acceptance | OOO | OOO | OO | - | - | - |

The issues with the broadest requirements and highest degree of relation for childcare robot design are *Quality*, *Comparative Media*, *Teamwork*, and *User Expectation*. Because *Quality* is related to the contribution of robots towards living standards it is basically connected to every requirement. *Comparative Media* represents the complex channels the robot will effectively use to differentiate it from previous media, and is thus related to every requirement. Next, *Teamwork* is needed to provide the robot with effective compromise and communications such as to act as an

effective mediator and assistant between mother and child, and therefore is related to all requirements, and highly related to Entertainment, Monitoring, and Scheduling. For effective communication robot design must coincide with what the user expects with regard to *User Expectation*. Childcare robots must fulfill the expectations of two separate users: the mother and the child, and must have two carefully separated interfaces. Issues related to this separation are *Naturalness, Personality, Relationship* must all be designed separate. Finally, due to the special circumstances for the Korean family, *Cultural, Acceptance* must also be taken into consideration.

By analyzing the robot design issues in regards to the primary requirements for childcare robots, we end up with the following conclusions. Emotional Response is the most sensitive aspect and is related evenly to every robot issue. In addition, like Emotional Response the Entertainment aspect of the robot is also related to all of the issues because the robot will be used as a playmate for children. For Communication, by using various mediums effective and clear communication is important such that *Comparative Media, Naturalness, User Expectation, and Quality* are related to Communication. Also since Education requires the effective use of various media for study and development of children's social skills *Comparative Media, Quality, and User Expectation* must be taken into consideration. Monitoring is related to health and safety so *Quality* should be considered, also since Monitoring is done in the place of the mother *Teamwork* becomes another important related issue. Additionally, since effective remote monitoring is required *Comparative Media* must also be considered. Finally, in regards to Scheduling *Quality and Teamwork* related issues become the most important.

4. 2. CHILDCARE ROBOT DESIGN GUIDELINES FOR DUAL-INCOME HOUSEHOLDS

By quantifying the importance of robot design issues based on frequency of primary requirements weighted by degree of correlation between primary requirements and robot design issues(0-3) for dual-income households we arrive at the figures shown in [Table 2].

Using quantified degree of importance in robot design issues we propose the following guidelines for childcare robots in dual-income households. Here we used robot design issues with an importance of 40 or more as the basis for design guidelines. Therefore the primary requirement of 'Entertainment' was not included.

Table 2: Degree of importance in robot design issues for dual-income households.

| Dual-income households | Scheduling | Communication | Monitoring | Emotional Response | Education | Entertainment |
|------------------------|------------|---------------|------------|--------------------|-----------|---------------|
| Frequency(%) | 30.6 | 19.1 | 15.9 | 15.3 | 13.4 | 5.7 |
| Comparative Media | 30.6 | 57.3 | 47.7 | 45.9 | 40.2 | 17.1 |
| Naturalness | - | 57.3 | - | 45.9 | 26.8 | 17.1 |
| User Expectation | - | 57.3 | 31.8 | 45.9 | 40.2 | 17.1 |
| Quality | 91.8 | 57.3 | 47.7 | 45.9 | 40.2 | 11.4 |
| Relationship | - | 19.1 | - | 45.9 | 26.8 | 17.1 |
| Teamwork | 91.8 | 19.1 | 47.7 | 30.6 | 26.8 | 17.1 |
| Personality | - | 38.2 | - | 45.9 | 26.8 | 17.1 |
| Cultural | - | 38.2 | - | 45.9 | 13.4 | 17.1 |
| Acceptance | - | 38.2 | - | 45.9 | - | 17.1 |

(1) Childcare assistance to relieve insufficient time constraints

The most important problem of dual-income households is one of Scheduling, or more concretely the insufficient amount of time due to assisting the child, and conflicts in schedules between mother and child. Robot design issues of *Quality* and *Teamwork* being considered the robot must efficiently assist in childcare and manage the mother and child’s schedules. By assisting the child in tasks such as changing clothes, eating, and preparing for school in the place his mother, the robot can create an excess of time for the mother to enjoy as her own. In addition the robot must have effective teamwork with the mother in assisting in childcare. In order for the mother and the robot to create an effective team, the responsibilities of the mother and those of the robot must be well divided, and the interface must be designed with the mother as the user in mind. Specifically, the time a dual-income household mother spends can be divided into the time she spends at work and the time she spends at home. Depending on the mother’s schedule the robot should be flexible and adaptive in changing its tasks and functions. For example, while the mother is away at work, messaging capability should be activated in order to transmit the child’s current state to the mother. While the mother is at home doing housework, the robot can assist in any childcare work. By effective management of both mother and child’s schedule the robot can help increase the quality of life.

(2) Assistance of effective communication between mother and child

For dual-income households the requirement for Communication in effectively persuading and explaining to the child was the second most cited requirement, the issues related to Communication are *Comparative Media, Quality, User Expectation, and Naturalness*. Due to differences in opinion between the mother and child, the child can sometimes throw tantrums in order to get his way and it is difficult for the mother to persuade him otherwise. The robot can utilize its various sensory media to better help the mother communicate with her child and persuade him. For example, if the child were to spend too much time watching TV, the robot can use its various media to stir the child's curiosity towards other directions. In addition the robot may persuade the child in his mother's place. For the robot to be effective in persuading the child, the robot's interaction such as appearance, language, voice, and gesture must be designed in consideration of the child's expectation.

(3) Physical and psychological monitoring

As dual-income families cited 'Removal of harmful contents' as the most frequent Monitoring requirement, related issue are those of *Quality, Teamwork, and Comparative Media*. To protect the mental well being of the child, the robot must be able to screen him from harmful contents. By using various sensory media, the robot can prevent the exposure of the child from harmful contents in the absence of the mother. In contrast to other mediums a robot has mobility and can therefore have the advantage of being able to follow the child while monitoring him. For a successful monitoring, effective teamwork between the robot and the mother is required. For example, if the mother who is at work is monitoring her child through the robot, development of a tool for remote control of the robot such that the mother can monitor the child from afar in real time. Thus from the control vantage the usability for the mother, and the interaction vantage the usability of the child must be taken into consideration during the design of the robot's interactions.

(4) Support for the effective Emotional Response of household members

For dual-income families the 'The importance of sharing time and space between household members' had the highest frequency of the Emotional Response requirement, and the related design issues for this requirement are *Quality, Comparative Media, User Expectation, Naturalness, Personality, Relationship, Cultural, and Acceptance*. For the busy dual-income family the robot can provide Emotional Response support between family members increasing their quality of life. Basically, the conditions for the robot to become accepted as a messenger and the relationship

between household members and the robot must be defined. In addition, for the robot to successfully transmit the emotions and experiences of the household members, the robot must provide natural interactions expected by each separate member, while applying the family's cultural peculiarities of communication style. Also, the appropriate personality of the robot as a messenger must be considered. By using the robot's visual, auditory, and tactile senses, family members can examine the state of other members and share experiences with each other. For example, a mother at work and her child at day care can be aware of each others' emotional state by sounds, facial expressions, heart rates, etc. Also, the robot can transmit the senses of a child that he or she perceives at one place to the mother at another place, thus allowing indirect sharing of time and place between mother and child from afar. Additionally, by using its various contents and sensory media the robot acts as a catalyst in helping family members to share time together.

(5) Effective study through various sensory media

Dual-income families had high frequency for 'Effective use of various mediums for education' and 'Education through appropriate positive reinforcement' requirements from those among Education requirements, and the related issues were *Quality, Comparative Media, and User Expectation*. Robots can provide diverse and beneficial educational contents through various media. In addition to 'singing, reading books, displaying educational materials' the robot's mobility can be used to provide educational contents such as 'follow dance steps, draw pictures' and so forth. For the robot to effectively support the education of the child, the mental model and abilities of the child should be considered in interaction design. Also the robot should provide appropriate rewards and compliments to provide an effective and pleasant learning experience. Interaction design of a robot based on 'reinforcement theory' to increase the achievements of children in mathematics(Kwak, Lee, Lee, Han, Kim, 2006, 2007) is a good example for the effects of appropriate praise and rewards.

4. 3. CHILDCARE ROBOT DESIGN GUIDELINES FOR SINGLE-INCOME HOUSEHOLDS

By quantifying the importance of robot design issues based on frequency of primary requirements weighted by degree of correlation between primary requirements and robot design issues(0-3) for single-income households we arrive at the figures shown in [Table 3].

Table 3: Degree of importance in robot design issues for single-income households.

| Single-income households | Education | Emotional Response | Scheduling | Monitoring | Communication | Entertainment |
|--------------------------|-----------|--------------------|------------|------------|---------------|---------------|
| Frequency(%) | 35.9 | 19.5 | 15.9 | 14.8 | 9.4 | 4.5 |
| Comparative Media | 107.7 | 58.5 | 15.9 | 44.4 | 28.2 | 13.5 |
| Naturalness | 71.8 | 58.5 | - | - | 28.2 | 13.5 |
| User Expectation | 107.7 | 58.5 | - | 29.6 | 28.2 | 13.5 |
| Quality | 107.7 | 58.5 | 47.7 | 44.4 | 28.2 | 9 |
| Relationship | 71.8 | 58.5 | - | - | 9.4 | 13.5 |
| Teamwork | 71.8 | 39 | 47.7 | 44.4 | 9.4 | 13.5 |
| Personality | 71.8 | 58.5 | - | - | 18.8 | 13.5 |
| Cultural | 35.9 | 58.5 | - | - | 18.8 | 13.5 |
| Acceptance | - | 58.5 | - | - | 18.8 | 13.5 |

Using quantified degree of importance in robot design issues we propose the following guidelines for childcare robots in single-income households. Here we used robot design issues with an importance of 40 or more as the basis for design guidelines. Therefore the primary requirements of 'Communication' and 'Entertainment' were not included.

(1) Effective study through various sensory media

In single-income households the requirements for Education was the most frequently cited, especially the secondary requirements for 'Effective use of various mediums for education,' and 'Education through experience' were rated high by mothers. The robot must be designed to assist efficiently in the child's education by taking the robot issues of *Quality, Comparative Media, User Expectation, Naturalness, Relationship, Teamwork, and Personality* into consideration. Previous works on the application of robots towards education include the application of Robovie to English education(Kanda, et al., 2004), the application of IROVIE to English, Korean, and music classes(Han, Kim, 2006), the application of PaPeRo to edutainment(Osada, 2005), and the use of AIBO as a storyteller and listener to storytelling of a child(Decuir, Kozuki, Matsuda, Piazza, 2004).

In addition to visual and auditory interfaces robots can provide tactile interface and provide a more diverse and beneficial quality of education contents. Not only does a robot provide visual and auditory interfaces for 'singing, reading, and displaying educational materials' as previous devices have, but a robot can also provide tactile and mobile functions for 'following dance steps, and drawing pictures.' In particular a robot can support education through experience by demonstrating how to brush teeth, change clothes, and even instruct not to use profanity by using its sensory media. In order for the robot to effectively support the child's education, design must take into account interactions which consider the child's mental model and abilities so that the child can naturally accept the robot. Previous research done regarding children's mental models of robots are as follows: children's perception on robots(Woods, Dautenhahn, Schultz, 2004, 2005; Han, Lee, Cho, 2005), the assessment of children's perception of PaPeRo(Ito, 2001), and a study on the design of the physical appearance of the expected Role Image for a teaching assistant robot(Ryu, Kwak, Kim, 2007). In addition for a robot to be effectively applied in teaching, the relationships between robot and child, parent, and teacher must be well defined, and the division of roles between robot and user must be considered. The personality of the robot must also be defined by its chosen role.

(2) Support for effective Emotional Response between household members

For single-income families the most frequent Emotional Response requirement was for 'Displays of affections through various mediums', and the related design issues for these requirements are *Quality, Comparative Media, User Expectation, Naturalness, Personality, Relationship, Cultural, and Acceptance*. The mother from a single-income family who has much time to spend with her child contemplates on deeper and richer ways to express emotions to her child. Robots will be able to be a new media for the expression of emotions, and should increase the quality of life for its users. Human emotional expression through use of robots is a sensitive area in which various robot design issues must be considered. The most basic requirements for a robot to become an effective method of expressing emotions are for the robot to become an accepted method for delivering emotional responses and for the social relationship between robot and human to be defined. In addition not only must the users' mental model and cultural traits be taken into consideration during design of the robot's interaction, but the personality given to the robot should also be taken into account. Research being done towards appropriate personalities for robots include works done with Big5(Goetz, Kiesler, Powers, 2003) and MBTI(Kwak, Kim, 2005). Family members can communicate their emotions using the robot's visual, auditory and tactile channels. In contrast to previous media, robots can use their mobility in tactile communications. Using the

tactile channels of a robot, family members can share touching and physical closeness with each other. HUG(DiSalvo, Gemperle, Forlizzi, Montgomery, 2003) and Hamie(Kwak, Kim, Kwak, 2001) are good examples of current work being done with respect to this channel of communication for robots.

(3) Childcare assistance to relieve insufficient time constraints

Single-income households cited 'Lack of time due to assisting children' as the most common Scheduling requirement, and the issues to this requirement were *Quality and Teamwork*. Similar to dual-income households, by assisting the child in tasks such as changing clothes, eating, and preparing for school in the place his mother, the robot can create an excess of time for the mother to enjoy as her own. To support the child a robot can either directly help him, or have an alarm function to remind the child of his duties such that the child can perform his duties on his own. For example, after the child finishing eating, the robot can bring the child a toothbrush or suggest that he brush his teeth. Additionally, in order for the robot to support the child it must have efficient teamwork with the mother. The roles of mother and robot for supporting the child should be well divided, and the interface should be designed with the usability by the mother in mind.

(4) Physical and psychological monitoring

For single-income families the requirement for 'Dietary health management' was the requirement most cited, and related design issues are *Quality, Teamwork, and Comparative Media*. Diets are an important factor for determining the health of growing children. The robot can utilize its various sensory media to monitor the child's snacking and eating amount. The robot can determine which foods are healthy and which foods are harmful to the child and encourage the child to eat healthier foods while warning him against unhealthy choices. For example, to a child who refuses to eat spinach, the robot can show visuals of children suffering from malnutrition due to the lack of vitamins found in spinach, or show Popeye cartoons depicting the benefits of spinach in order to persuade the child. Also the robot can warn the child against excessive snacking in place of the mother, while explaining the negative effects of snacking. Additionally the robot can provide the mother with updated menus and information on eating habits for the health of the child. There must be effective cooperation between mother and robot for the robot to successfully monitor the child's eating habits. Therefore interaction design for the robot must be done with the mother in mind for control and the child in mind for usability. Also, in order to maintain regular eating schedules and vitamin intake, the robot should have an alarm function.

5. CONCLUSION

The goal of this work was to present robot design guidelines for single and dual income families through an ethnographic study for analysis of the life styles with regard to childcare. We were able to extract requirements in childcare by in-depth interviews with mothers, home tours of participating families, and one-week childcare journals kept by the mother. Six primary requirements of Scheduling, Education, Communication, Emotional Response, Monitoring, and Entertainment were determined and secondary requirements were also abstracted. Dual-income families were more concerned with Scheduling and Communication requirements, while single-income families cited Education and Emotional Response as more important requirements. In order to create robot design guidelines for each type of household, the importance of robot design issues was quantified by frequency of primary requirements weighted by degree of correlation between requirements and issues. The childcare robot design guidelines for single and dual income families were presented with the respective priority, similarities, and differences. In future works we plan to use these guidelines in designing a childcare robot and evaluate usability and users' satisfaction level for single and dual income families.

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