



Can Robots Help Working Parents with Childcare? Optimizing Childcare Functions for Different Parenting Characteristics

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Abstract

Is it true that parents always prioritize educational effectiveness when selecting childcare services? The current study identified the potential requirements of dual-income parents toward social robots' diverse childcare functions (e.g., *socialization*, *education*, *entertainment*, and *consultation*). The results revealed that parental attitudes toward robots were made more positive by all the childcare functions of robots except for their educational features. Furthermore, parents' expectations of childcare functions varied based on their parenting characteristics. Spectral clustering analysis identified distinctive parenting styles (e.g., *family-oriented*, *work-oriented*, *noninterventive*, and *dominant*), and multigroup structural equation modeling suggested that the impact of robots' socialization function was significant in all parent groups, while other childcare functions exerted limited influence according to specific parenting styles. In addition, children's characteristics were found to alter parents' preferences for each childcare function. These results offer practical implications for the early adoption of childcare robots through predetermining parents' acceptability based on their specific parenting characteristics.

Keywords Social robots · Childcare robots · Children–robot interaction · User experience

1 Introduction

Today, robots provide people with mental and psychological aid by performing actions such as talking to them in daily life, exchanging information, and sharing intimate feelings. These *social robots* are physically embodied artificial agents designed to display socially appropriate and meaningful behaviors to interact and communicate naturally with humans [1–3]; thus, they are capable of interacting with human users to ameliorate the quality of their daily life. Recent advancements in machine learning and artificial intelligence technologies have sparked active exploration of areas where robots' social capabilities can be applied. For example, studies on children–robot interaction have suggested ways in which effective learning can be triggered by

employing the social capabilities of robots to develop robot-generated learning content in classroom environments [4–6]. In addition, with their interaction capabilities, social robots can enhance the persuasive quality of conveyed messages [7, 8], reduce stress, and provide emotional relief for children [9], going beyond mere educational purposes. Moreover, another line of research has explored the use of robots to conduct wide-ranging activities for parenting, including parent–child communication [10], entertainment [11–13], and the maintenance of children's behavioral records [14]. Given the benefits they can offer, social robots are expected to play various roles in children's development.

Among the many application areas of social robots in children's development, the present study focused on using social robots to support parenting in the home environment. Of special interest are dual-income parents, as they are expected to be early adopters of childcare robots. Such parents are concerned that the insufficient time they have to devote to parenting tasks may hinder the cognitive and emotional development of their children [15, 16]. Therefore, dual-income parents endeavor to provide superior social experiences to their children [16, 17, 81], and utilize alternative parenting services more keenly [15]. For these reasons, social robots can be designed to bridge the gaps in

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nurturing that confront dual-income parents to satisfy their parental demands [18, 19]. These robots can potentially support many parenting functions as well as compensate for the paucity of emotional interaction experiences for children of dual-income parents who find it difficult to focus on childcare.

Despite the high interest in children–robot interaction, relatively little attention has been paid to the use of childcare robots in home settings. Relevant studies have mainly focused on how robots can effectively provide educational content to improve learning outcomes [6]. Consequently, parents have attracted little attention despite being the primary decision-makers for their children. Since childcare robots are expected to be used in family home environments, an investigation of parental needs regarding childcare robots will provide critical insights. Moreover, parents' preferences and expectations of childcare robots are likely to vary across families, because each family has different parenting styles and childcare environments. Thus, the differences between families should be considered when designing childcare robots. Lastly, although childcare social robots can offer a variety of functions, little is known about the relative importance among those functions. By comparing numerous functions simultaneously, specific functions that exercise a greater impact on shaping a positive attitude can be more accurately ascertained.

In light of the aforementioned discussion, the present study proposed the following general research question to produce development guidelines for childcare robots that support parenting.

General Research Question For dual-income parents with different parenting characteristics, what are the differences in their preferences for robots' childcare functions?

To address this research question, the present study first explored dual-income parents' needs in childcare. Then, it suggested a range of childcare-support functions of robots based on the identified parental needs. Next, the study examined the presumption that these childcare features can elicit positive responses from parents toward such robots, and compared the relative importance among the parenting-support functions. Finally, the present study investigated the differences in parents' preferences for robots' childcare functions based on their different parenting characteristics.

2 Related Works

2.1 Social Robots for Childcare Service

Due to existing parenting challenges, childcare robots have attracted significant scholarly attention. Robots with various interaction techniques, including touch interfaces, facial recognition, and natural conversation, are expected

to play numerous childcare roles; they can deliver messages between parents and children, and they can be playmates, conversation partners, and tutors [20, 21]. In addition, a line of studies has suggested ways to support parenting, such as education, entertainment, and the building of social bonds with children. As for educational application, a care-receiving robot, for instance, enables a child to learn through teaching the robot English vocabulary and how to do handwriting, as opposed to the child being taught by the robot [22, 23]; furthermore, in-home robots can improve children's motivation and interest in learning [24, 25]. In addition to providing academic aid, robots are used to teach children how to choose healthy diets [26]. Regarding entertainment, home telepresence robots support childcare; one such robot plays with children while parents are doing housework and, through a head-mounted display, they are able to remotely take care of their children simultaneously [18]. Another telepresence robot is teleoperated by adults to interact with their babies/toddlers [27]. Childcare robots can also be used as tools for building social skills. These socially interactive robots can assist children with autism spectrum disorders [28] by diagnosing and understanding autism and helping children with autism to develop their social skills [29]. Moreover, children can establish social bonds by interacting with robots that act as friends and mentors to them [9].

While existing works on childcare robots have mainly focused on children's perceptions of the robots, their parents have attracted relatively little attention. Indeed, parents are the main subject of parenting, and parenting is a journey involving both parents and children; thus, parents must be considered in the design of childcare robot services. Lin et al. [30] found that parents' acceptance of childcare robots requires not only simple functions but also profound interaction quality provided by the robot; therefore, they suggested that a more in-depth exploration for latent factors would be necessary. This perspective is particularly critical because children are highly influenced by their parents, and parental attitudes toward robots are important in children's use of robots [31]. For example, parents who consider reading books together to be crucial for social bonding might be worried about using a storytelling robot [30], and they would likely not allow the robot to read books to their children. Such a negative attitude toward a robot would have a negative effect on the children's attitudes toward that robot [31]. Thus, it is essential to understand the needs of parents and what functions they desire in childcare robots, as well as for parents to have a positive attitude toward such robots.

2.2 Parents' Childcare Needs

According to papers on parents' employment and children's well-being, many working parents are concerned about the lack of time they spend with their children as well as

housework, which might negatively affect children’s affective and cognitive development [32, 33]. In particular, social interaction time spent between parents and children on education and conversation, which require high concentration and participation from both parties, positively predicts children’s social and affective development. Parent–child interactions encourage primary social learning. Parents’ educational activities for their children, such as reading books, require active verbal communication; therefore, reading books with parents improves not only the child’s cognitive development but also their emotional development. In the same vein, parents and children spending time together on homework, play, and housework has a positive effect on children’s social development—even if these are not direct educational activities—because they require high participation as well as effective communication from both parties [16, 17]. On the other hand, childcare time with little parent–child interaction was found to be nonsignificant or even negative for a child’s development [34].

Based on the aforementioned discussion, it can be concluded that providing children with rich social and communication experiences is more effective than securing maximum parenting time when establishing parenting strategies for dual-income parents. Providing children with quality social experiences is surely seen as a crucial goal in raising them. Indeed, dual-income parents tend to reduce household chores and personal duties [81] to maintain quality social interaction time with their children [16]. In other words, dual-income parents attempt to increase the amount of quality time spent with their children, and compensate for insufficient parenting time [35] with parenting quality [16]. In addition, parents encourage children to actively interact with social partners such as friends, teachers, relatives, and companion animals to form social relationships [33] because they value socialization in childcare settings.

Parents’ needs in raising their children predict how childcare robots will be used in home environments. Kwak et al. [19] conducted in-depth interviews with dual- and single-income parents and identified six primary childcare requirements for childcare robots: education, entertainment, communication, emotional response, scheduling, and

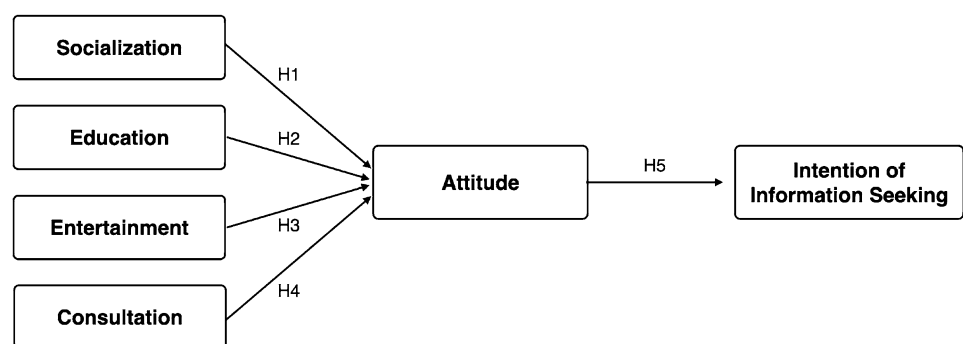
monitoring. Their results revealed that dual- and single-income families exhibited different preferences for childcare robots. Working parents required scheduling because they have time restrictions when managing childcare and housework. By contrast, for single-income families, an educational application appeared to be the most critical aspect. Moreover, both family types considered entertainment and monitoring of their children’s physical and psychological activities as important. In summary, parents expect childcare robots to provide social experience, educational, and entertainment content. In addition, such robots must support parents through providing sufficient information about their children’s development.

3 Hypothesis Statements

Based on the discussion in the previous section on parents’ needs in childcare, the present study suggested the following childcare functions of social robots: socialization, education, entertainment, and expert counseling. Figure 1 presents the proposed model of this study and describes the relationships between parents’ expectations of childcare functions, their attitude toward childcare robots, and their willingness to seek more detailed knowledge.

According to use and gratification (U&G) theory, end-users choose and consume media technologies that satisfy their needs [36]. Dual-income parents are highly aware of their parenting needs and actively engage in exploring and employing services that can satisfy their requirements. These qualities are congruent with the user characteristics assumed by U&G theory. The U&G framework explains how the needs of end-users promote media consumption across the spectrum—from traditional media to new media [37, 38]. The flexible methodology offered by the U&G perspective also provides grounding for research on state-of-the-art technical features of emergent media devices. Hence, it allows for the investigation of the ways in which devices such as social robots can influence the psychological needs of users and how they may shape behaviors with respect to technology use [39]. In this manner, state-of-the-art

Fig. 1 Proposed research model



technology can generate new needs and expectations in users, and services utilizing media technology can be designed to satisfy the distinct needs of their target users.

Substantial research endeavors on the subject of U&G and on the technology acceptance model (TAM) have evidenced that the attitudes and perceptions of users toward specified media and technology were positively influenced by user expectations that they would satisfy their needs [40–42]. Consequently, a more favorable parental attitude is expected to be generated toward childcare robots if parents have high expectations from the parenting-support functions of robots.

3.1 Parental Expectations from the Socialization Function of Robots

Through their imaginative interactive capabilities, social robots encourage children to engage actively in communication [43, 44] and generate satisfactory personal relationships with children [9]. Social robots can consult with children about their concerns [45], and if necessary, they can also offer children advice that adheres to the demands of social ethics. Childcare robots can also be used to socialize children and to instill socially desirable behavior in them, which is a parenting issue of particular concern for dual-income families. Accordingly, we proposed the following hypothesis:

Hypothesis 1 (H1) Double-income parents will form a favorable attitude toward a robot based on their expectations of its socialization function for their children.

3.2 Parental Expectations from the Education Function of Robots

Social robots are likely to become one of the most advantageous educational tools along with writing supplies and computers [6]. Compared with virtual agents displayed only on a screen, robots that have physical bodies have been reported to enhance the effectiveness of educational content by encouraging participation from learners [5, 6, 46]. The educational content programmed into childcare robots boosts children's concentration, and thus, tends to generate superior learning effects compared with traditional video and image-based educational material. If parenting robots can provide high-quality educational content, dual-income parents will probably use robots to help their children achieve better academic outcomes [19]. Accordingly, we proposed the following hypothesis:

Hypothesis 2 (H2) Double-income parents will form a favorable attitude toward a robot based on their expectations of its educational utility for their children.

3.3 Parental Expectations from the Entertainment Function of Robots

Physically formed robots can interact tangibly with children to produce a dynamic and authentic recreation environment that is more interesting than the mere playing of entertainment content. Robots can interact directly with children by performing actions such as dancing [13] or by playing board games with them [12]. Furthermore, parents desired childcare robots to be programmed with the ability to play with children while they are busy with household chores or when they desire some personal time [19]. According to the relationship between the expectations and attitudes of dual-income parents with regard to the entertainment function of robots, this study proposed the following hypothesis:

Hypothesis 3 (H3) Double-income parents will form a favorable attitude toward a robot based on their expectations of its entertainment function for their children.

3.4 Parental Expectations from the Consultation Expertise and Advisory Functions of Robots

Parents value the advice of experienced childcare professionals [33] and will appreciate robots that can deliver the recommendations of expert consultants to their children [19]. Through their capability for direct interaction, childcare robots can also encourage children to speak freely about their concerns [45]. Further, parenting robots can record any unusual behavior displayed by children for expert reference, and parents responded positively to this recording function [14]. Therefore, parenting robots can act as beneficial tools for the collection of behavioral data on children, and can also help to deliver these data to specialist counseling agencies, enabling parents to obtain appropriate professional advice. Accordingly, the fourth hypothesis was formulated as follows:

Hypothesis 4 (H4) Double-income parents will form a favorable attitude toward a robot depending on their expectations from its counseling expertise and advisory functions for their children.

3.5 Parental Intentions to Seek Information

An individual's intentions toward a specific behavior are generally considered pivotal to the actual performance of that behavior [47, 82]. A person's attitude toward a particular behavior is a key contributor to the shaping of his or her personal intentions, an assertion that has been validated by a series of conceptual frameworks including the theory of reasoned action [82], the theory of planned behavior [47], and the TAM [48]. The TAM identifies the process through

which users accept and utilize novel technologies. Thus, positive parental attitudes toward childcare robots are likely to contribute to parental intentions to accept and use them. The present study characterized the behavioral intentions of parents to adopt childcare robots through their plans to research information about the robots in more detail. This attribute was specified because of the absence of viable childcare robots in the current marketplace. Since parents cannot yet directly or indirectly experience the usage of social robots, their iteration of future information-seeking intent could provide a more accurate and practical result regarding their prospective acceptance and utilization of robots that support parenting tasks. Employing this rationale, the relationship between parental attitudes toward childcare robots and the intentions of parents to seek additional information about the technology was postulated in the following hypothesis:

Hypothesis 5 (H5) The positive attitude of dual-income parents toward robots will enhance their intentions to seek more detailed information about robots.

3.6 How Parenting Characteristics Influence Functional Expectations

3.6.1 Influence of Parenting Styles

In addition to the aforementioned hypotheses about the functions of childcare robots, the current study also investigated whether parental preferences for individual functions of social robots would vary according to the divergent parenting styles exhibited by dual-income parents. In fact, both single- and dual-income parents, whose parenting environments differ, prioritize the desired parenting functions of robots in contrasting ways. The ultimate desire of double-income parents is to efficiently manage schedules and optimally utilize their insufficient parenting time. On the other hand, single-income parents find the educational functions of robots most crucial [19]. Similarly, if the impact of specific parenting styles on parents' functional preferences for robots can be confirmed, social robot makers will be able to offer customized functions for parenting robots for specific households. Therefore, validating the correlations between particular parenting styles and parental preferences for each of the four aforementioned functions of childcare robots is worthwhile.

Darling and Steinberg [49] defined parenting style as “a constellation of attitudes toward the child that are communicated to the child and that, taken together, create an emotional climate in which the parent’s behaviors are expressed.” Long-standing interest in different parenting styles has been primarily aimed at predicting child development, and researchers have sought to identify parental behaviors that can predict child development [83]. Currently, the method of

Baumrind is the most widely used categorization model [50, 51]. Baumrind used two dimensions, namely demandingness and responsiveness, and derived a four-fold classification of parenting styles: authoritarian, permissive, authoritative, and rejecting-neglecting. Based on existing discussions for categorizing parental behaviors, the present study used *parenting time* as the most important concept for clustering the parenting style of dual-income families. Such families have been increasing in number recently, and they typically lack time for parenting compared with single-income families [16, 19]. A recent study found that the average number of working hours for a dual-income couple is 41 per week, with 2.5 h to commute, for a total of 43.5 h outside the home, while their children spend 30 h a week at school on average. As a result, these children spend an average of 13.5 h alone each week [52]. Indeed, according to existing studies, time investment in children has a positive effect on child rearing and the quality of life of children [53–56]. For dual-income parents who work for a long time, it is difficult for them to secure time with their children, meaning they cannot participate in various parenting activities. Thus, the choices parents make to compensate for their lack of childcare, including their use of time and childcare services, can be essential factors for categorizing parenting styles. In this context, this study developed the following research question to probe the relationships between parenting styles and parental preferences for specific utilities served by childcare robots:

Research Question 1 (RQ 1) Do variations in the time devoted by parents to childcare and differences in duration of parental absence, along with the use of in-home childcare services, induce dissimilar parental attitudes toward robots' childcare functions?

3.6.2 Influence of Children's Characteristics

Children's unique characteristics, such as their age and sibling status, can also alter parents' social robot acceptance. Children exhibit distinct developmental patterns as they grow, and thus, parents may prioritize childcare activities differently. Indeed, theoretical discussions on children's sociocognitive development have argued that parents should emphasize appropriate developmental tasks for their children in accordance with their stages of development [57]. For example, parents of early-childhood children are recommended to encourage their children to explore the world on their own, whereas parents of mid-childhood children need to encourage their children to feel confident in their abilities. That is, in the process of their sociocognitive development, children first learn how to act with their own will before being able to evaluate the consequences of their own actions. In addition, children's developmental status influences their social interaction style. A series of empirical studies have consistently reported that younger children are relatively

passive in social processes, whereas older children are active [58–61]. Regarding this tendency for passive interaction of young children, Saarni [62] explained that young children suppress emotional expressions because they are immature in how they express emotions, and therefore, they worry that incorrect expression will lead to negative consequences.

In addition, children's developmental status has a critical influence on their interaction with robots. Studies have reported that young children are more sensitive to the sociality of robots [63, 88]. For example, young children under the age of 9 years perceived robots as social beings only through their appearance, whereas older children perceived robots as social beings through more sophisticated interactions [64]. Similarly, another study indicated that children aged 6 to 7 years exhibited favorable perceptions regardless of the robot's personality and interaction style [65]. However, the same study also confirmed that children between the ages of 8 and 11 years could distinguish the detailed social characteristics of robots. Children aged between 8 and 14 years, relatively older in this context, did not exhibit significant differences in the shaping of their attitudes and perceptions of robots [66]. In other words, as Shahid [67] indicated, younger children are more likely to simply enjoy interacting with robots rather than assessing their social capabilities in depth. Despite these prior studies, empirical evidence and theoretical discussions remain lacking, making it difficult to accurately predict the impact of children's age on their acceptance of childcare robots. Therefore, to explore how parents' preferences for various parenting functions of robots vary with the age of children, this study developed the following research question:

Research Question 2 (RQ 2) How does children's childhood stage change their parents' attitudes toward robots' childcare functions?

Another child-oriented factor that determines parents' attitude toward a childcare robot is sibling status. Siblings are essential partners in social interaction, play, and mutual learning, and thus, they have a great influence on children's growth. A pervasive stereotype exists that children without siblings—only children—are narcissistic, arrogant, and self-righteous; therefore, parents of only children are concerned about the appropriate emotional development of their child [84, 85]. Indeed, many studies have presented counterarguments to this stereotype; for example, children's social development is determined by their parents' interests and quality social experiences [68], and an only child may even surpass other children with siblings in social development because they can monopolize on social interaction with their parents [69, 70]. However, the subjects of the present study are dual-income parents, who are generally concerned about insufficient interaction with their children. Despite the aforementioned counterevidence, concerns about their child's proper social development can be a very real problem for

these parents. Therefore, to explore the difference between parents with a single child and parents with multiple children, this study proposed the following research question:

Research Question 3 (RQ 3) What are the differences in parents' attitudes toward robots' childcare functions between single-child and multi-child families?

4 Data

4.1 Measurements

The current study examined the childcare needs of parents by conducting a thorough examination to test the proposed research model and hypotheses. It created questionnaire items on parental expectations for childcare functions of social robots because these features have not yet been reviewed by researchers. Previous studies have adopted two measurement variables, *attitude toward robots* [71] and *intention to search information* [72]. An electronic questionnaire was administered to respondents, who were required to indicate their degree of agreement with each item on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). The whole items are provided in Appendix I.

4.2 Respondents

The developed questionnaire was distributed to 624 double-income families in South Korea. Table 1 presents the demographic characteristics of the respondents. All respondents were mothers ($N=351$) or fathers ($N=273$) raising a child or children aged between 3 and 12 years. To explore the research questions regarding children's age and sibling status, children's characteristics were considered when gathering data. Of the 624 families, 204 parents had an early-childhood child (aged 3–7 years), 210 parents had a middle-childhood child (aged 8–12 years), and 210 parents were raising two or more children (aged 3–12 years). In this study, the early-childhood children were preschoolers, and middle-childhood children were schoolers, as the childhood groups were determined by the age that a child enters elementary school in Korea (8 years of age in Korean age corresponds to 6–7 years of age by Western measurements). The majority of respondents ($N=506$) were full-time employees, and 17.8% of the participating parents ($N=111$) denoted family units in which one parent worked full-time and the other was a part-time employee. The remaining seven parents were having temporal parental leave or working from home. We included these family units in the analysis because they still lacked a full-time guardian for their children. Even though only one of the parents worked full-time at their workplace, part-time and home-working parents in this study spent more than six hours a day working on average, and

Table 1 Demographic characteristics of respondents and their children

Group	Characteristics	Details	Frequency (N)	Percentage (%)
Parents	Gender	Male	273	43.8
		Female	351	56.3
	Age	20–29	5	0.8
		30–39	308	49.4
		40–49	310	49.7
		50–	1	0.2
	Employment Type	Both Full-Time Employees	506	81.1
Full and Part-Time Employees		111	17.8	
Others		7	1.1	
Children	Single Child	Early Childhood (3–7)	204	32.6
		Middle Childhood (8–12)	210	33.7
	Multiple Children	Aged between 3–12	210	33.7

they also had nearly two hours of absence in parenting. The respondents were aged between 27 and 50 years, with most being in their 30 and 40 s.

4.3 Data Validation

An exploratory factor analysis was conducted on the 15 expectation items using principal component analysis. An orthogonal Varimax rotation method was also employed to identify the underlying structure of parental expectations from the discrete childcare functions of robots (see Table 2). As anticipated, the factor analysis extracted the four predetermined expectation attributes relating to the childcare functions of robots. These functions were labeled entertainment, education, socialization, and expert

consultation. In addition, the internal consistency of each of the identified factors was calculated using Cronbach's alpha, and the reliability values of all expectation categories were found to be above the adequate level.

The convergent and discriminant validity of the measured data were assessed through a comparison of the internal consistency of each variable and its correlations with the other variables. Table 3 demonstrates the average variance extracted (AVE) values of each latent variable as well as the inter-construct correlations. The square root of the AVE of each latent variable should be higher than its correlation value with any other constructs [73]. As the results in Table 3 indicate, the latent variables were reliable and valid.

Table 2 Results of the exploratory factor analysis of parental expectations of robot features

Items	Factor Loadings			
	Expectation of Entertainment ($\alpha = .891$)	Expectation of Socialization ($\alpha = .860$)	Expectation of Education ($\alpha = .813$)	Expectation of Expert Consultation ($\alpha = .855$)
Exp_Ent 1	.854			
Exp_Ent 2	.815			
Exp_Ent 3	.815			
Exp_Ent 4	.700			
Exp_Soc 1		.827		
Exp_Soc 2		.820		
Exp_Soc 3		.765		
Exp_Soc 4		.675		
Exp_Edu 1			.821	
Exp_Edu 2			.718	
Exp_Edu 3			.652	
Exp_Edu 4			.589	
Exp_Con 1				.830
Exp_Con 2				.807
Exp_Con 3				.783

5 Results

5.1 Hypotheses Testing

The present study employed structural equation modeling (SEM) to test the hypotheses and answer the research question. The statistical indices relating to the fit of the proposed research model evidenced that the chi-square (χ^2) indicator for the model was significant at $\chi^2(198, N=624)=723.844$, $p < 0.001$, and the $\chi^2/\text{degrees of freedom (df)}$ ratio was 3.66. In terms of other indices, the root mean square error of approximation (RMSEA) was computed at 0.065, the incremental fit index (IFI) was 0.941, and the comparative fit index (CFI) was 0.941. These results indicated acceptable fitness of the proposed model.

Figure 2 outlines the estimation results for the SEM analysis of the proposed model. As demonstrated in the figure,

except for expectations of the education function, parental expectations of varied childcare functions in robots predicted their positive attitudes toward robots. The results also evidenced that the more positive a parent’s attitude toward robots, the stronger that parent’s reported intention to seek additional information about robots.

Table 4 presents the results obtained from testing this study’s hypotheses. It is evidenced that parental expectations from the socialization feature (H1) of robots exerted a positive effect on their attitudes toward childcare robots. Similarly, aspirations for entertainment (H3) and expert consultation (H4) facilities predicted more positive parental attitudes. However, the findings did not demonstrate a positive association between hopes for educational features (H2) in robots and positive parental attitudes toward them. Given the numerous studies on the educational effectiveness of social robots, this surprising result must be further

Table 3 Test results of convergent and discriminant validity

Variables	AVE	C. R	Socialization	Education	Entertainment	Expert consultation	Attitude	Information seeking
Socialization	0.720	0.910	0.849					
Education	0.658	0.884	.576**	0.811				
Entertainment	0.780	0.933	.497**	.612**	0.883			
Expert Consultation	0.783	0.915	.477**	.554**	.532**	0.885		
Attitude	0.805	0.943	.551**	.462**	.465**	.466**	0.897	
Information Seeking	0.803	0.924	.520**	.493**	.463**	.496**	.685**	0.896

Diagonal elements represent the square root of the AVE; off-diagonal elements indicate correlations between constructs

Fig. 2 Estimation results relating to the proposed model

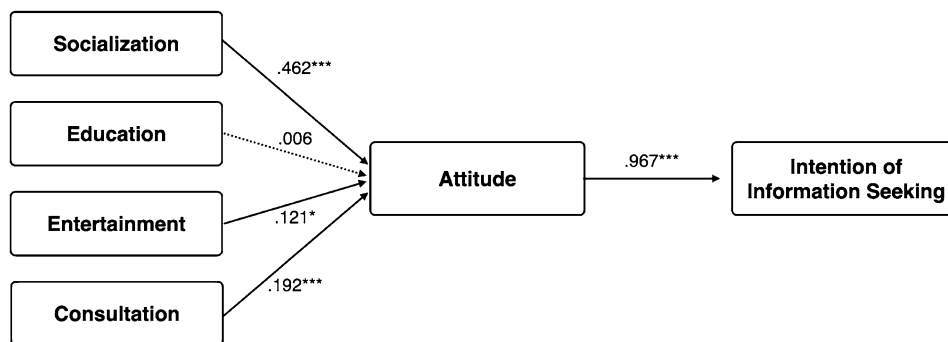


Table 4 Results of the testing of the hypotheses

Hypotheses	Standardized estimate	Unstandardized estimate	S. E	C. R	P
H1: Socialization→ Attitude	0.451	0.462	0.064	7.229	***
H2: Education→ Attitude	0.060	0.006	0.080	0.076	.939
H3: Entertainment→ Attitude	0.125	0.121	0.053	2.259	.024
H4: Expert Consultation→ Attitude	0.221	0.192	0.047	4.114	***
H5: Attitude→ Intention to Seek Information	0.783	0.967	0.055	17.431	***

scrutinized by ascertaining whether particular characteristics of diverse parenting styles hinder or facilitate parental desires regarding the educational features of robots. The next section discusses this issue further. The results validated H1, H3, and H4, but H2 was not supported. Moreover, H5 was confirmed in that parental attitudes toward childcare robots were ratified as significant predictors of their intentions to seek further information.

5.2 Exploring Differences in Parenting Styles

The general and specific research questions were proposed to explore how different parenting characteristics alter parents' preferences for robots' respective childcare functions. More specifically, RQ 1 queried whether different parenting styles generate divergent needs in childcare functions. To investigate the potential influences of parenting styles, the present study conducted clustering analysis to identify different parent groups and then compared them using a multigroup SEM analysis.

5.2.1 Clustering Data by Distinctive Parenting Styles

Spectral clustering analysis was conducted to categorize respondent parents according to their parenting styles. The spectral clustering technique classifies distinctive subgroups that are different from each other and that demonstrate similar in-group characteristics [74]. The analysis employed for the present study comprised three characteristics of parenting styles: the time parents expended on household chores, the time children spent alone (i.e., time that parents could not engage in childcare), and whether parents used supplemental in-home childcare services (e.g., a nanny, grandparents). As Table 5 exhibits, the analysis identified four subgroups of families with different parenting styles. The number of subgroups was determined using the eigengap heuristic method [74] and also with the k -fold cross-validation method, where the k was 10 and the accuracy of the clustering result was estimated at 99.52% [75].

Parents designated to the first cluster spent more than four hours every day doing housework. Their commitment to parenting indicated that their children were not alone for too long despite the fact they utilized fewer in-home childcare services. Conversely, the parents in the second cluster spent

less than an hour on housework, and these parents were relatively active in the use of in-home childcare support. The parents classified in the first two clusters were respectively labeled *family-oriented* and *work-oriented*. The parents allocated to the third and fourth clusters were similar in terms of the amount of time they expended on household chores: both groups of parents spent approximately two hours a day on housework. However, these parents differed in the time they could not engage in childcare and the ratios of their use of at-home childcare support. The parents assigned to the third group were comparatively reluctant to use extra childcare services; however, the fourth group demonstrated the highest use ratio for external services among all the clusters. More importantly, the children in the third group were left unsupervised for more than four hours per day, whereas those in the fourth group spent most of their time under adult supervision. The parents in the third group were thus named *noninterfering*, and those in the final cluster were called *dominant*. Noteworthy in this context is that while the number of children between these groups was similar, the ages of the children were not. The children of parents in the *noninterference* cluster (i.e., the third group) were relatively older ($M=9.479$, $SD=2.494$) than the children of *family-oriented* parents ($M=7.218$, $SD=2.558$), *work-oriented* parents ($M=7.089$, $SD=2.411$), and *dominant* parents ($M=7.160$, $SD=2.540$).

5.2.2 Influence of Parenting Styles on the Shaping of Parental Attitudes Toward Childcare Robots

A multigroup SEM analysis was performed on the clustered groups of parents with discrete parenting styles. This analysis was aimed at investigating the potential changes in parental attitudes toward robots according to the variations in expectations exhibited by the four clusters. Before comparing the expectations that contributed to the shaping of parental attitudes, the inter-group measurement invariance was tested through nested comparisons using gradually constrained models (Table 7). The configural equivalence between the groups was supported by the overall fit indices of the model: $\chi^2(792) = 1549.884$, $p < 0.001$, $\chi^2/df = 1.957$, IFI = 0.918, CFI = 0.916, and RMSEA = 0.039. Table 6 demonstrates that a series of the critical ratio of differences was nonsignificant when measurement weights

Table 5 Results of spectral clustering analysis

Variables (Unit)	Cluster 1 ($N=165$) Mean (SD)	Cluster 2 ($N=135$) Mean (SD)	Cluster 3 ($N=204$) Mean (SD)	Cluster 4 ($N=120$) Mean (SD)
Time Spent on Housework (Hours per day)	4.120 (1.584)	0.960 (0.207)	2.200 (1.322)	2.000 (0.00)
Time Children Spent Alone (Hours per day)	0.600 (0.847)	0.250 (0.436)	4.250 (3.489)	0.330 (0.473)
Use of Childcare Support at Home (0 = none, 1 = use)	0.620 (0.486)	0.710 (0.455)	0.630 (0.485)	0.740 (0.440)

Table 6 Results of the measurement equivalence test for parent groups

	χ^2	df	IFI	CFI	RMSEA	$\Delta\chi^2$	Δ df	<i>p</i>
Unconstrained model	1549.884	792	0.918	0.916	0.039			
Measurements weights	1580.964	840	0.919	0.918	0.038	31.080	48	0.972
Structural weights	1591.229	855	0.919	0.919	0.037	41.345	63	0.984
Structural covariances	1633.734	885	0.918	0.917	0.037	83.850	93	0.741
Structural residuals	1651.295	891	0.916	0.916	0.037	101.411	99	0.414
Measurement residuals	1772.551	957	0.910	0.910	0.037	222.667	165	0.002

(factor loadings), structural weights (regression weights for predicting *attitudes* and *intentions of seeking information*), structural covariances (factor variances and covariances), and structural residuals (variances in *attitudes* and *intentions of seeking information*) were constrained to be constant across the groups. This result supports the equivalence of the measurement across the parent clusters even though a significant difference was found in the most constrained model, which additionally included measurement residuals to be constant across groups.

The subsequent multigroup analysis revealed that the expectations from the childcare functions of robots that can generate positive parental attitudes toward robots differed from group to group. Table 7 displays that the socialization function of robots was positively associated with parental attitudes toward robots across all groups. No inter-group statistical differences were found in these estimated coefficients for the socialization function. Thus, parents were consistently motivated to use robots to improve their children's social skills regardless of their parenting styles. By contrast, parental expectations from the educational features

of robots did not predict parental attitudes in any of the clusters. Additionally, parental expectations from the expert consultation and advisory facilities of robots only exercised a positive effect on the attitudes of parents categorized into the *noninterfering* cluster ($\beta=0.342$, $p<0.01$). Furthermore, the parental desire for entertainment features in robots predicted positive attitudes only in parents designated into the *dominant* group ($\beta=0.247$, $p<0.05$). However, it was confirmed in all clusters that an increase in positive parental attitudes toward robots caused a congruent strengthening of their intent to seek more information about robots.

5.2.3 Influence of Children's Ages on the Shaping of Parental Attitudes Toward Childcare Robots

Along with parenting styles, various characteristics of children will affect parents' acceptance of childcare robots. In particular, the second research question (RQ 2) concerned the influence of children's age. To explore how children's age alters parents' expectations regarding each childcare function, a multigroup SEM analysis was

Table 7 Results of the multigroup analysis of parents groups of different parenting styles

Path	Family-oriented Parents				Work-oriented parents			
	standardized estimate	unstandardized estimate	S. E	C. R	standardized estimate	unstandardized estimate	S. E	C. R
Socialization→ Attitude	.460***	.592***	0.156	3.786	.631***	.547***	0.100	5.483
Education→ Attitude	.031	.031	0.137	0.224	.016	.015	0.140	0.106
Entertainment→ Attitude	.086	.084	0.105	0.800	.079	.078	0.114	0.682
Expert Consultation→ Attitude	.159	.142	0.098	1.460	.170	.132	0.082	1.615
Attitude→ Intention to Seek Information	.752***	.940***	0.105	8.940	.754***	.909***	0.114	7.997
Path	Noninterfering parents				Dominant parents			
	Standardized estimate	Unstandardized estimate	S. E	C. R	standardized estimate	Unstandardized estimate	S. E	C. R
Socialization→ Attitude	.306**	.301**	0.115	2.616	.368*	.338*	0.145	2.331
Education→ Attitude	.004	.004	0.165	0.022	.144	.167	0.225	0.741
Entertainment→ Attitude	.127	.124	0.113	1.090	.247*	.206*	0.095	2.170
Expert Consultation→ Attitude	.342**	.297**	0.092	3.225	.072	.062	0.104	0.601
Attitude→ Intention to Seek Information	.829***	1.046***	0.103	10.180	.773***	1.027***	0.141	7.292

* $p<.05$, ** $p<.01$, *** $p<.001$. 5.3. Exploring differences in children's characteristics

performed with the early ($N=204$) and middle ($N=210$) childhood groups. Parents in each group were raising only one child, specifically aged either three to seven or eight to twelve in Korean age, mainly preschoolers and schoolers. Similar to the previous analysis, a nested comparison test supported the equivalence of measurements across the children’s groups (Table 8).

The subsequent multigroup analysis confirmed the differences in parents’ expectations between different age groups. As presented in Table 9, robots’ entertainment function did not improve parents’ attitude in the early childhood group, whereas parents of middle-childhood children were predicted to have a more favorable attitude from the entertainment function ($\beta = 0.212, p < 0.05$). Although education function did not significantly influence parents’ attitude toward robots in either age group, parents’ preference for socialization and expert consultation functions led to more positive attitudes regardless of their children’s age. The beta coefficient of the influence of expert consultation on attitude was higher in the middle-childhood group ($\beta = 0.316, p < 0.01$) than that in the early childhood group ($\beta = 0.240, p < 0.01$), indicating that parents of middle-childhood children may consider robots’ expert consultation function to be more crucial.

5.2.4 Influence of Children’s Sibling Status on the Shaping of Parental Attitudes Toward Childcare Robots

The third research question (RQ 3) explored how the number of children in families changed parents’ attitudes toward childcare functions. More specifically, this study investigated whether parents of a single child exhibited a stronger preference for childcare robots. The study data were from 414 single-child families and 210 multi-child families, and a multigroup analysis was conducted to compare these two groups. The configural and metric invariances between groups were confirmed, as presented in Table 10.

The results of the comparison are presented in Table 11. In line with the previous results, the socialization function consistently predicted parents’ favorable attitudes in both groups, whereas the education function did not. The most notable difference was in the robots’ entertainment function. In the only-child group, parents’ expectations of the entertainment function significantly increased their attitude toward robots, indicating that parents raising a single child prefer robots to provide entertainment content ($\beta = 0.165, p < 0.05$). By contrast, parents of multiple children did not display such a preference for the entertainment function. This result provides preliminary evidence for the initial assumption that parents of a single child may have a stronger

Table 8 Results of the measurement equivalence test for children’s age groups

	χ^2	df	IFI	CFI	RMSEA	$\Delta\chi^2$	Δdf	p
Unconstrained model	792.558	396	0.931	0.931	0.049			
Measurements weights	809.034	412	0.931	0.93	0.048	16.476	16	0.42
Structural weights	811.679	417	0.931	0.931	0.048	19.121	21	0.577
Structural covariances	826.511	427	0.93	0.93	0.048	33.953	31	0.327
Structural residuals	826.803	429	0.931	0.93	0.047	34.245	33	0.408
Measurement residuals	868.188	451	0.927	0.927	0.047	75.63	55	0.034

Table 9 Results of the multigroup analysis of children’s age groups

Early childhood group	Standardized estimate	Unstandardized estimate	S. E	C. R	P
Socialization→ Attitude	0.416	0.496	0.128	3.873	***
Education→ Attitude	0.008	0.009	0.122	0.074	0.941
Entertainment→ Attitude	0.145	0.140	0.087	1.606	0.108
Expert Consultation→ Attitude	0.240	0.206	0.077	2.682	0.007
Attitude→ Intention to Seek Information	0.777	0.927	0.09	10.278	***
Middle childhood group	Standardized estimate	Unstandardized estimate	S. E	C. R	P
Socialization→ Attitude	0.414	0.466	0.116	4.002	***
Education→ Attitude	- 0.179	- 0.220	0.195	- 1.125	0.26
Entertainment→ Attitude	0.212	0.262	0.124	2.112	0.035
Expert Consultation→ Attitude	0.316	0.306	0.116	2.648	0.008
Attitude→ Intention to Seek Information	0.785	0.914	0.087	10.535	***

Table 10 Results of the measurement equivalence test for children's sibling status groups

	χ^2	df	IFI	CFI	RMSEA	$\Delta\chi^2$	Δ df	<i>p</i>
Unconstrained model	948.859	396	0.938	0.938	0.047			
Measurements weights	965.833	412	0.938	0.938	0.046	16.974	16	0.387
Structural weights	969.699	417	0.938	0.938	0.046	20.84	21	0.469
Structural covariances	988.007	427	0.937	0.937	0.046	39.149	31	0.149
Structural residuals	993.627	429	0.937	0.936	0.046	44.769	33	0.083
Measurement residuals	1027.895	451	0.935	0.935	0.045	79.037	55	0.019

Table 11 Results of the multigroup analysis of children's sibling status groups

Only child group	Standardized estimate	Unstandardized estimate	S. E	C. R	<i>P</i>
Socialization→ Attitude	0.428	0.488	0.084	5.773	***
Education→ Attitude	− 0.059	− 0.067	0.106	− 0.632	0.528
Entertainment→ Attitude	0.165	0.178	0.072	2.482	0.013
Expert Consultation→ Attitude	0.248	0.226	0.064	3.548	***
Attitude→ Intention to Seek Information	0.775	0.910	0.063	14.547	***
Multi-child group	Standardized estimate	Unstandardized estimate	S. E	C. R	<i>P</i>
Socialization→ Attitude	0.487	0.410	0.094	4.387	***
Education→ Attitude	0.180	0.150	0.116	1.292	0.196
Entertainment→ Attitude	0.012	0.009	0.078	0.121	0.903
Expert Consultation→ Attitude	0.157	0.124	0.066	1.880	0.060
Attitude→ Intention to Seek Information	0.799	1.088	0.114	9.575	***

preference for childcare robots because of the lack of parenting time. Parents' expectations of the expert consultation function also differed between the two groups; families of a single child were predicted to prefer the function ($\beta=0.248$, $p<0.001$), whereas multi-child families were not. Notably, the beta coefficient was higher in the only-child group than in the multi-child group. Thus, even though the expert consultation function's influence approached significance in the multi-child group, the function should still be prioritized for only-child families.

5.3 Follow-Up Open-Ended Survey

Social robots are still in their infancy, and thus, few people have used them. Therefore, in the main questionnaire of this study, only dual-income couples with children were surveyed, but not those who had experience of using social robots. To overcome this limitation, an additional survey was conducted on 23 people who had experience with social robots to investigate their motivations and expectations from such robots. Respondents responded to open-ended survey questions, and a total of 21 respondents' data were analyzed; two respondents' data were excluded because their answers were incomplete. Of the 21 respondents, 73.913% were women, and they had an average of 1.762 children.

Their average age was 41.429 years, and they worked for an average of 19.763 h per week, with an average time spent on housework of 2.810 h on weekdays and 4.725 h on weekends.

When asked about their motives for using social robots, the respondents' answers included the following: "I am worried that my children cannot meet friends because of COVID-19," "If the robot was like a friend that helps my child's social development, it would be nice," and "I use social robots to understand my child's disposition and aptitude and to know their emotions that day." An analysis of their responses revealed the motivations for using social robots were education, play, the child's disposition, child safety, and consultation with experts. Specifically, the motivation for education (66.666%), play (42.857%), grasping the propensity of children (19.048%), and socialization (19.048%) was high. In addition, when asked about their expectations for social robots for children, they gave answers such as, "I think learning is important for children's robots, but it would be nice if they could be a friend to a child alone" and "I would like to give detailed feedback and praise so that the child can be motivated." The analysis revealed that the respondents expected the robot would be convenient to use (33.333%) and that it would give children pleasure (23.810%).

The results of the open-ended survey of people with experience with robots supported this study’s hypotheses as being well established. As previously mentioned, education, play, and socialization were the most critical motives for parents to consider, and some answered that they wanted consultation with experts, albeit a low proportion (4.762%).

6 Discussion

6.1 Summary of the Results

Figure 3 illustrates the estimated regression coefficients of each childcare function of robots on parents’ attitude toward robots by their respective parenting characteristics. As shown in the figure, childcare robots’ socialization function was predicted to improve dual-income parents’ attitudes across all parenting characteristics. By contrast, none of the parenting characteristics led parents to shape the need for robots’ education function. Robots’

entertainment function was expected to have significant positive influences only for parents with dominant parenting styles, parents who are raising middle-childhood children, and parents of a single child. Finally, robots’ expert consultation function was confirmed to improve the attitude of parents with a noninterfering parenting style and those of a single child, as compared with parents with different parenting styles and multiple children. Children’s age did not alter the need for the expert consultation function, which exhibited a significant influence for parents of both early- and middle-childhood children.

6.2 Optimization of Childcare Robots for Different Parenting Styles

The results of this study indicated that dual-income parents displayed divergent expectations from the parenting-support functions of social robots, which depended on their own parenting styles. This outcome can offer practical implications for companies engaged in devising

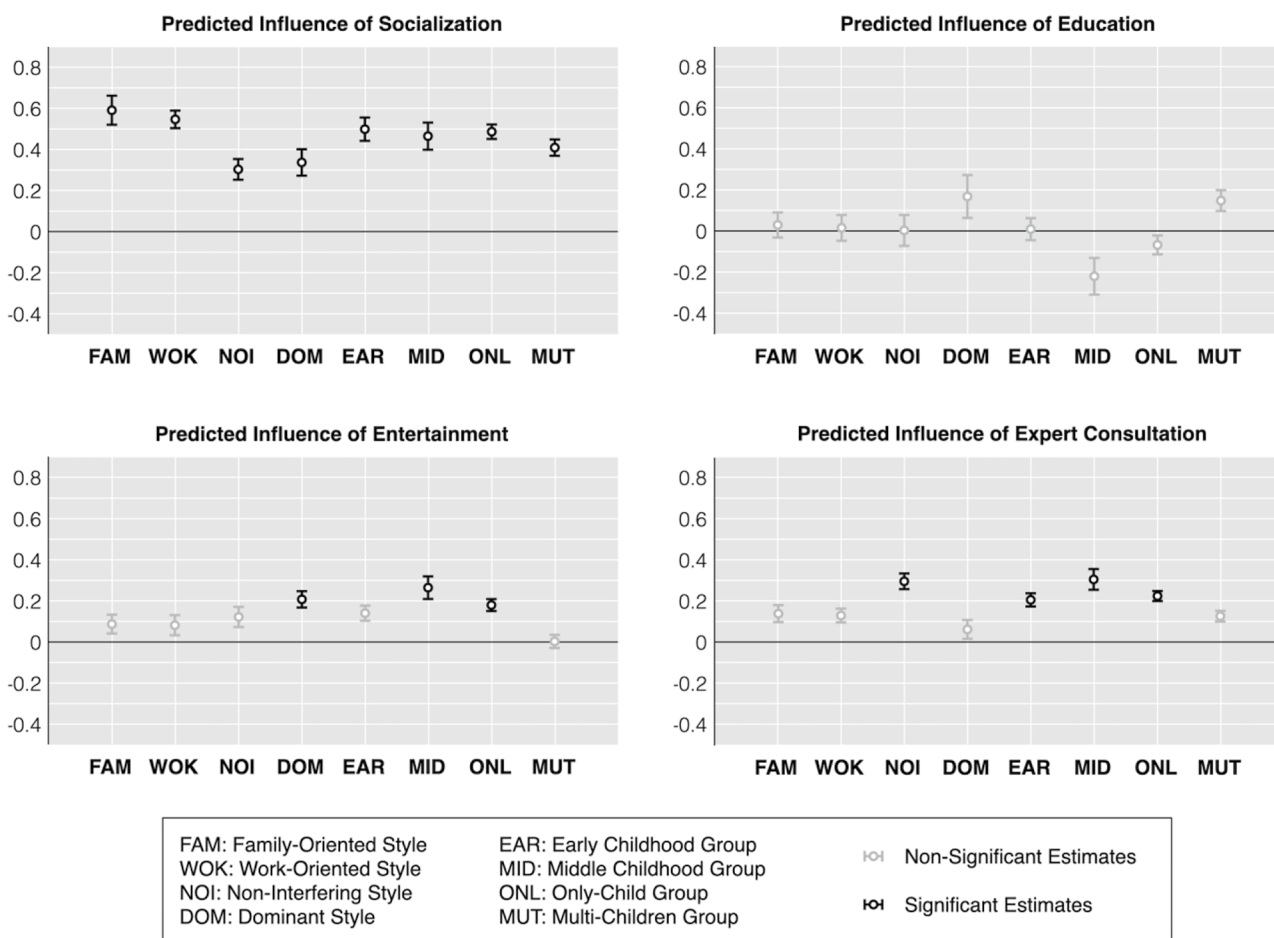


Fig. 3 Estimated influences of childcare functions

marketing strategies for childcare robots by suggesting that markets should be segmented according to distinct parenting needs. *Family-oriented* parents spent sufficient time on household chores and only demonstrated interest in the social interaction skills of robots that would help to improve the interpersonal skills and ameliorate the socialization of their children. *Work-oriented* parents were found to actively utilize alternative parenting methods to minimize childcare gaps, and this parenting characteristic is typical of dual-income parents. The economic benefits of dual-income parents allow such family units to avail high-quality parenting services (e.g., nursing) for their children [15]. Like *family-oriented* parents, *work-oriented* parents only reported aspirations for the social interaction functions of robots that could aid the enhancement of the interpersonal interaction skills of their children.

Noninterfering and *dominant* parents reported additional expectations for the functions of childcare robots. Parents in the *noninterfering* group were predicted to form a positive attitude toward social robots when the products could offer the service of enabling consultations with child development experts. The parents allocated to the *dominant* group were estimated to exhibit positive attitudes toward social robots when they were programmed to provide engaging entertainment content to children. This incongruous result can be explained by the age difference between the children of parents assigned to the two groups. As children become older, they require less direct nurturing from their parents and are increasingly able to undertake active decision-making roles while their parents are at work. As children mature, their parents are also likely to gain more career-related experience and are probably required to perform more responsible workplace roles. The children of parents allocated to the *noninterfering* group were more than two years older than those of parents assigned to other groups; thus, it is viable that their older children would spend an increased amount of time alone at home. As children are removed from parental supervision, parents tend to desire to become more relevant to their lives, such as through school activities or peers. In fact, one-way analysis of variance and Bonferroni post-hoc analysis results revealed that *noninterfering* parents exhibited statistically and significantly greater intentions to engage in parenting [$M = 3.788$, $SD = 0.615$; $F(3, 620) = 5.229$, $p < 0.01$, $\eta_p^2 = 0.03$] than the other groups (*family-oriented*: $M = 3.588$, $SD = 0.652$, *work-oriented*: $M = 3.583$, $SD = 0.581$, *dominant*: $M = 3.581$, $SD = 0.527$). Therefore, parents in the *noninterfering* group reported looking forward to the professional counseling functions of robots for their children, which would enable them to make efficient use of their limited parenting time and to

better understand the behaviors displayed by their children. On the other hand, the *dominant* parents anticipated the entertainment features of robots so that their children could be enjoyably engaged while the parents accomplished other chores.

6.3 Optimization of Childcare Robots with Children's Characteristics

Children's characteristics also provide implications for the development of childcare robots. For parents of younger children, their expectations for the robot's social interaction function and expert counseling function were predicted to improve their attitudes toward robots. In addition, the robot's ability to provide entertainment content was confirmed to form a positive attitude in parents of older children. This result suggests that the entertainment function of robots should be introduced more carefully when targeting young children. Excessive exposure to video content can hinder the cognitive development of younger children [76], and parents are concerned about the negative effects of media exposure. Therefore, it is recommended that the robot's entertainment function is mainly designed for school children.

The results also indicated that sibling status changes parents' attitudes toward robots. While parents of multiple children formed a positive attitude only for the socialization function of the robot, parents of only children were predicted to respond positively not only to the socialization function of the robot but also to the entertainment and expert counseling functions. This result is consistent with the general perception of parents of only children, namely that they have a tendency to actively search for parenting means to help their child's natural social development. In particular, even multi-child parents demonstrated clear needs for the socialization function of robots. These results suggest that dual-income parents, the subject of this study, can consider childcare robots as a way to provide higher quality social interactions to their children.

6.4 Implications for Developing Robots' Childcare Functions

While the socialization function of robots was significant in predicting positive parental attitudes in all four clusters, the educational features did not affect parental attitudes toward robots for any parenting style. These results are particularly noteworthy because numerous studies have validated the educational effects of robots in laboratories and classrooms. The low parental interest in the educational qualities of robots could be explained by the many educational alternatives already available

to parents from their homes. In fact, classroom robots generally represent only one type of specialized educational equipment. Conversely, parents are likely to prefer diverse educational functions of social robots in their homes. Therefore, the educational features of childcare robots targeted for the home environment must be designed using an approach that differs from the classroom environment. For instance, social robots should participate with children in the accomplishment of their tasks and collaborate with them to achieve task-related goals rather than simply offering access to relevant educational content [6, 22]. In a meta-analysis of the educational effects of robots, Belpaeme and his colleagues [6] found that only 9% of the studies utilized robots as colleagues, and not as mere content providers. The results of the present study could promote the scholarly exploration of alternative education-related roles for robots. Above all, this study affirmed that the need for quality social experiences for children was expressed consistently by all parents, regardless of parenting styles. It thus offers the crucial insight that childcare robots should prioritize the development of robots that can engage in natural and socially relevant interactions with children.

6.5 Limitations of the Study and Suggestions for Future Studies

Despite the promising results and implications, potential limitations should be acknowledged. First, the survey was administered online, and this mode may not have facilitated the clear iteration of the potential parenting needs with respect to childcare robots. In fact, parents who experienced childcare functions of robots in laboratory environments were reported to develop a more positive attitude toward robots than were those who responded to an online survey that included visuals of robots [14]. Although the open-ended survey supports the findings, the parents who participated in the main study had never used robots; thus, studies with individuals who attain a comprehensive understanding of the usage of robots are likely to identify novel requirements. Second, the parenting styles compared in this study were specifically derived on the basis of behaviors evinced only by the participants of the current investigation. It may be worthwhile for prospective investigations to verify the differences in parental expectations from robots through the classification of more generalized parenting styles. Thus, future researchers are encouraged to systematically compare parental motivations for the use of childcare robots depending on previously devised classifications of parenting styles. Third, the present study surveyed only

Korean parents. Indeed, existing studies have revealed cultural differences in parenting across different cultures. In the West, where individualism is developed, parents raise their children independently, and in the East, where collectivism is prevalent, parents raise their children to be obedient and tolerant [77]. In addition, parents in the East hesitate to leave their children with babysitters, whereas parents in the West use babysitters more commonly [14].

Regarding the limitations, it is noteworthy that recent social development across the world challenges cultural differences. Urbanization increases formal education opportunities [78], and the number of working parents has increased [86, 87], suggesting that parents from different cultures may share similar parenting goals and environments. Recent studies have revealed that Western parents also value etiquette, tolerance, and unselfishness [77], while Eastern parents also emphasize individualistic values, including children's independence and self-reliance [79, 80]. In this regard, the identified childcare functions may generally contribute to parents' attitude toward social robots. Still, future studies are encouraged to investigate how parents from different cultures exhibit distinctive preferences for respective childcare functions.

7 Conclusion

The present study identified social robots' childcare functions that may mitigate dual-income parents' difficulties in raising their children. With a research model based on the U&G framework, this study investigated how parents' expectations of each childcare function improve their attitude toward social robots. Furthermore, a range of parenting characteristics that alter parents' preferences for childcare functions was explored. The results suggested that social robots can help dual-income parents to raise their children by providing social interaction experiences and entertainment content to them, and by allowing parents to receive consultations from childhood development experts. Indeed, different parenting characteristics, such as parenting styles, children's age, and sibling status, were found to change parents' needs for specific childcare functions, implying that robots can optimize their functions for particular types of families. Thus, the results of the present study will help developers and business practitioners of childcare robots to strategically design and introduce their robots to their target consumer groups.

Appendix

Construct	Code	Items
Expectation of Socialization	Exp_Soc 1	I want robots' ability of social interaction that can help children to develop empathic ability
	Exp_Soc 2	It is important for robots to support children to develop their sociality
	Exp_Soc 3	I want robots to encourage children to be confident in their social relationships
	Exp_Soc 4	It would be nice if robots nudged children to express their own thoughts and emotions
Expectation of Education	Exp_Edu 1	I want robots to check whether children complete their homework
	Exp_Edu 2	It is important for robots to have a function of supporting children's studies
	Exp_Edu 3	It is important for robots to supervise children to be able to study by themselves
	Exp_Edu 4	It would be nice if robots could answer the questions that children are curious about
Expectation of Entertainment	Exp_Ent 1	I want robots to recommend entertainment content for children
	Exp_Ent 2	It is important for robots to have an entertainment function that can amuse children
	Exp_Ent 3	It is important for robots to know what entertainment content can please children
	Exp_Ent 4	It would be nice if robots could play with children when they are bored
Expectation of Expert Consultation	Exp_Con 1	When necessary, I want to get parenting consultations from education experts by using a robot
	Exp_Con 2	It would be nice if robots could connect me to child development experts
	Exp_Con 3	I want to communicate with child experts using a robot on various parenting concerns, including children's development and academic achievement

Construct	Code	Items
Attitude toward Robots	Attitude 1	Social robots give me a positive feeling
	Attitude 2	I think I will like social robots
	Attitude 3	By purchasing and using social robots, I think I can give a favorable impression to others
	Attitude 4	Social robots will have a socially desirable public image
Intention to Search Information	Inf_Seek 1	If social robots go on sale, I will look for more detailed information about the robots
	Inf_Seek 2	If social robots go on sale, I will compare the robots with other parenting services
	Inf_Seek 3	If social robots go on sale, I will search for viable purchasing options to get the robots at a reasonable price

Declarations

Conflict of interests The authors declare that they have no conflict of interest.

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