國立臺灣大學文學院圖書資訊學系

碩士論文

Department of Library and Information Science
College of Liberal Arts
National Taiwan University

Master Thesis

兒童圖書館機器人外觀與個人空間相關性之研究

Determination of active personal space based on appearance when interacting with a library robot

許文馨

Wen-Hsin Hsu

指導教授：林維真 博士

Advisor: Weijane Lin, Ph.D.

中華民國 103 年 6 月

June, 2014

Content

謝辭

一直覺得完成這份論文，從來都不是靠我自己一個人，而是因為有你們，我才能順利畢業。

在完成這份研究的過程中，我受到了好多人的幫助與體諒。每一場的實驗都要請 8 至 9 位的夥伴們到場協助，還要 Julia 和 Book Smile 兩隻機器人的配合才能順利完成。從一開始大量地閱讀文獻，到後來慢慢上軌道，開始學著規劃實驗、聯絡人力等，還有面對我最不喜歡的數學們，很難想像我真的完成了這一切。過程中雖然有過很不快樂的時候，也偶爾會發發牢騷，但還好我身邊有很多陪伴我的家人與朋友，讓我最後能順利走到這一步。

首先，我想想謝謝我的指導教授維真老師，每次都不厭其煩地和我討論要修改的地方，並給了我很多資源，也讓我在真正撰寫論文前，有一段試寫期刊的過程，使我在文獻回顧部分因為有了之前的訓練，更為快速地上手。還要感謝兩位口委老師，岳修平教授與傅立成教授給予我許多論文的意見與協助，謝謝岳老師 HP Lab 中的夥伴們悅綺、家蓁、慧軍、臨超與明心撥空協助支援實驗的人力；傅老師研究室中的士桓學長、仲達、靖螢、東諺、庭升、亦修、友騏、政賢、家明、韶廷與致昂在整個過程中協助我修改機器人的設定，給予了我許多建議，更在每場實驗中到場支援控制機器人。圖資所的同學與學弟妹們，聖昕、婕妤、俐伶、芷洛、中哲、慧雯、敏之、董芸與佩旻，謝謝你們協助擔任各場實驗中的工作人員，雖然偶有突發狀況，但因為有你們一切都順利地完成了。欣穎學姐則是

我在做實驗過程中的好夥伴和大支柱，如果沒有學姐的提點和協助，我可能會花更多的時間去摸索，因為有了你，讓我在作實驗的過程中好像吃了顆定心丸。還有 MM Lab 的夥伴們，謝謝千霆和淑媚幾乎是全程參與地幫我作實驗，不管是計畫書還是學位考試都有賴你們兩個，我才可以放心地去準備我的論文。我會很懷念和你們兩個一起在研究生研究室認真、玩鬧的時光的。

最後要謝謝我的家人，謝謝我的爸爸媽媽，謝謝你們一直支持我，給予我很大的自由空間，也讓我很任性地多讀書了一段時間，很謝謝你們；也很謝謝我的姐姐面對我的各種情緒，也包容我的各種反應。

無法用文字說出我對大家的感激與感謝，只能用不斷的謝謝來表達。

真的非常謝謝大家。

摘要

兒童讀者為公共圖書館主要的使用者族群之一。於生理上他們常因身高限制或是資訊素養的不足而須仰賴成人的協助，而於心理上他們亦習慣身旁有人陪伴，與父母或圖書館員一同使用圖書館服務。然而圖書館員礙於人力成本的限制，無法在同一時間服務所有讀者，經常使得兒童讀者的圖書館使用需求無法被滿足，或遭遇障礙。基於上述背景，本研究藉由引進圖書館機器人服務，提供陪伴、引導與圖書館利用指導，以滿足兒童讀者的需求與降低圖書館員的工作負擔。過去雖有相關文獻探討人與機器人互動情形，但多以瞭解互動態度為主，關注兒童之閱讀與資訊行為的相關研究較少。本研究以兒童讀者為主要研究對象，探討圖書館機器人與兒童讀者的互動空間與態度，並考慮兒童的性別、年齡等生理發展狀況，以及性別態度、社會化等心理發展情形，以進一步探討圖書館機器人在兒童進行高層次閱讀與資訊互動行為時的功能與角色。

本研究共招募 77 位臺北市國小三至六年級學童，將其隨機分配至各組別與不同外觀機器人在圖書館中互動。透過受測者在實驗過程中所保持的個人空間與事後填寫的問卷態度，來分析受測者對於機器人的想法。根據研究結果，受測者對於機器人抱持正面的態度，且在與機器人互動時感到自在。而其中發現機器人外觀會影響兒童讀者與機器人之間的互動：與擬人化外觀機器人互動的受測者所保持的個人空間較與擬機械外觀機器人互動的受測者近，與此距離內互動暗指受測者視圖書館為私密空間，並認為機器人為親密好友。此外，兒童讀者的性別亦

會影響互動過程，當與機器人互動時兒童偏向與自己同性別之機器人在較近的空間中互動，且女孩對機器人保持更為正面的態度。本研究在樣本資料收集與測量上突破先前研究之困難，提供兒童讀者與圖書館機器人互動之實證研究支持，對於圖書館引入機器人服務也能做為參考，期望在研究與實務上都能發揮價值。

關鍵字：圖書館機器人、兒童讀者服務、個人空間

Abstract

The child patron is one of the major user groups in the public library. Physically, they often need adults' help to access library services because of height's limits or lack of library information literacy; psychologically, they are used to be accompanied by adults or librarians when using the services in the library. However, due to the limit of human resources costs, librarians cannot serve all users in one time. This results in the dissatisfy of library need of child patrons

Based on the above background, this study provides accompanying, guide and the instruction of library use to meet child patrons' need and to reduce librarians' workload by introducing the library robot service. Although there were researches about the interaction between human and robot, these researches mainly focused on investigating the attitude of interaction, but not on the reading and information behaviors of children. This study used child patrons as the main object to investigate the personal space and attitude between the library robot and child patrons. Also, considering the children's physiological development, such as gender and age, and their psychological development, such as gender role and socialization, this study further explored the function and role that the library robot played when child patrons were doing high level of reading and information interacting behaviors.

This study recruited 77 elementary students from 3rd-6th grade from Taipei city and assigned them randomly to interact with robots with different appearances in the library. The personal space that the participants kept with different appearance robots and the attitude they had to the robot were recorded and analyzed. The result showed that the participants had positive attitude to the robots and felt comfort when interacting with robots. What's more, the appearance of robots would affect the interaction process: the one that interacted with human-like robot kept the personal space closer than the one that interacted with machine-like robot. This space indicated that the participants took the library as a private space and thought the robot as their close friend. Besides, the gender of the participants would also affect the personal space and the attitude that the participants had to the robot. Child patrons tend to keep the personal space from the robot closer when robots were the same genders as they were. Also, the girl had more positive attitude than the boy as well.

This study broke through past difficulties of the collection and measurement of sample data and provided the empirical research of the interaction of child patrons and library robots. The results can also be the reference when introducing the robot service to the library.

Keywords: library robot, reader service for children, personal space

List of Figures

List of Tables

1. Introduction

1.1 Research background and motivation

For many public libraries, child patrons are one of the major user groups, and they are also the most active users in the library (Benton Foundation, 1996). Viewing children as the future clients, public libraries actually devote many efforts to do researches or activities for child patrons. To list a few, child patrons' activities in libraries are various, such as borrowing collections, reading books, using computers, and watching movies (Becker, 2012). However, difficulties may be encountered due to child patrons' physical limits or literacy skills that hindered their use of the library resources, such as their height to reach the bookshelves, and their lack of information literacy to orient themselves in the library environment. It is often that child patrons need and require librarians or adults' help to get library services and resources; therefore an assistive agent is of help to child patrons' library use.

From reaching, lifting, to computing, robots have been served as the agent to assist human users to perform a variety of physical and intellectual activities (Parry, 2011). With the agency roles and functions, users' needs, behaviors and acceptance to the robots are important to collect whenever robots are introduced to a scenario. Previous studies in human-robot interaction have suggested several factors that are important including robots' appearance (Coradeschi et al., 2006; Syrdal, Koay,

Walters, & Dautenhahn, 2009), users' features and their perceptions of robots (Nomura et al., 2008). However, studies regarding child users are few (Banik, Gupta, Habib & Mousumi, 2013; Balasuriya, Watanabe & Pallegedara, 2007), and the understanding of children's attitudes toward robots remains limited due to insufficient or unempirical supports.

Human interaction involves various intentions and actions that reflected these intentions. A typical representation of the phenomena is described by Hall (1966) as the "personal space," where people stay in a certain distance in an interaction to show their intentions to interact with the others and the current situation (Reeves and Nass, 1996). When the distance between two people is short that may mean their relationship is close, and vice versa. Studies regarding the human-robot interaction support that the personal space also appears inevitably (Walters et al., 2005) that reflects human intentions to interact with the robots. In addition, another critical but less-explored factor that affect human-robot interaction is contextual effects (Ham et al., 2012). Contextual cues are what people sense and rely on to proceed with conversations, and cannot be overlooked in the exploration of any interaction.

Motivated by the aforementioned issues, this study intends to explore child patrons' interaction with robots by assessing the interpersonal distance under a specific context of library. In addition to the general exploration on human preference

and performance in the human and robot interaction (HRI), it is expected to understand more profoundly the activities and intentions people possessed through the systematical investigation of interaction context and structural measurement of interpersonal distance.

1.2 Research purpose and research question

This study investigates the personal space and the attitude that child patrons possessed under different kinds of contexts in order to better understand child patrons' thinking toward the library robots. Specifically, the research questions are listed as follows:

(1) Will different appearances of the robot affect the child patrons' attitude and personal space toward the robot when the child patrons and the robot are interacting in the library?

(2) Will the child patrons' age and gender affect their attitude and personal space toward the robot when they and the robot are interacting in the library?

2. Literature review

2.1 Child patrons' development

The mission of the public libraries to serve child patrons is to build the connection between children, collections, and the information (鄭雪玫，1991; Walter, 2001). In order to make the sufficient connection, the most and first important measure that libraries take is to understand their users, such as child patrons' developmental characteristics（鄭雪玫，1991）, their preferences and limitations (Walter, 2003). The following sections review child patrons' mental developments in gender role and reading, the two aspects that are related to children's interaction behaviors in library settings.

(1) Children's reading development

Wood (2007) categorizes children's reading features in different stages. In the 1st-2nd grade, children tend to read with others, mostly in group. They do not start to read independently until their 3rd to 4th grades. For the 5th-6th graders, they prefer reading the book that contains certain topics like history, sports and science fictions, where the scenarios, stories and characters can be extensively discussed and shared. Wood's findings, with reference to the local studies in Taiwan（陳幗眉、洪福財，2001）support that primary education is the stage where children's reading strategies and information needs are developing and refining. For the children in this stage, to

provide them with appropriate and adaptive reading instructions that fit their capabilities and preferences can be influential.

(2) Children's gender role development

Kohlberg's (1966) theory defines the three stages of children's cognitive development in gender roles. From the first stage of basic gender identity where children recognize their own sex and distinguish other's gender by appearance, to the second stage of gender stability, it is argued that children of their 4 to 6 years old are well-developed in gender identities and start to exert their cognition of gender roles in everyday activities. Children in 6 to 7 years old reach the third stage of gender consistency; they understand the fact that a person's gender is inherent and consistent even when a person is not acting like his/her innate sex. It is also when the gender stereotypes start to form. Shaffer (2009) proves that children in their school ages (8-12 years old) focus more on the gender differences while they use gender-typed behaviors to understand and process different genders. It is argued that children have made a cognitive judgment about their identity before selecting same sex models for sex-typed behaviors. Especially for the 3rd to 6th graders, their gender awareness is gradually higher, and they use appearances including hair styles, facial features, clothes, accessories and gestures to distinguish one's gender. According to the maturity of physical development, girls' gender awareness is higher than boys, and the

older children's gender awareness is higher than the younger's（黃鳳娟，2013）.

2.2 Child patrons' in libraries

According to American Library Association (ALA), the public library is the kind of library that serves its community's residents library collections and other services without service charge (Young, 1983). Also, the law of library in Taiwan defines the public library should serve the public with library information service, cultural activities, and social education（圖書館法，2001）. To summarize, the public library's mission and task is to serve the community with all kinds of services. For many public libraries, child patrons are one of the major, and the most active user groups (Benton Foundation, 1996). Also, according to Walter (2003), up to 60% of public libraries' users were the people whose age was under eighteen. Additionally, among students of all stages, whose age between 7 to 12 years old possesses the highest check-out rates in Taiwan, and the rate has been steadily growing every year since 1997（臺北市立圖書館，2012）.

For child patrons, libraries is an information gateway, social interaction/entertainment space; and library as beneficial social environment. These child patrons do variety activities in the library, like using computers, doing homework, looking for information etc. to access libraries' services and collections. As the age grow, children in different stage of age had different behavior and need in the library. For example, since the children were in the preschool age, they have been

accompanying by their mother to visit and use the library. By being accompanying, the children can learn browsing the bookshelves, picking out books, and speaking with librarians, etc (Becker, 2012). That's why when locating books to read, browse or borrow in the library, shelve browsing is the most popular strategy that children use (Raqi & Zainab, 2008; Wicks, 1995; Agosto, 2007). When children are in the elementary school age, they start to learn how to use the library from teachers and librarians. For them, how to find the sources they like, and follow the library regulation on their own is a new topic（詹棟樑，1994）. Subdividing the elementary stage, according to the Tolbert (1980), when children are in the 1st-2nd grade, they start to learn being independent and to get familiar with their school surroundings; when they are in the 3rd- 4th grade, they start to notice their decision making process, like what the motivation and the need is. Also, children in this stage will explore the surrounding and form their own behavior patterns. When they are in the 5th-6th grade, they not only focus on their selves, but external environment. They have their own interest and goal. During the decision making process, they also search others' support and approve as their goal to success.

However, due to the lack of library information literacy and some physical limits (child patrons' height), child patrons often need the librarians' help to get the collection or other library services when their parents are not accompanying with

them. For example, child patrons' information searching often have problems in developing searching strategies on library's OPAC（曾淑賢，2001）; the height of child patrons is different from adults, therefore parts of collections in the higher bookshelves are hardly taken by child patrons without any assistance（蘇國榮，2013）.On the other hand, based on the importance of children to public libraries, the librarians do lots of efforts on children services, like homework help, computer accessing, storyline, book selection and other outreaches (Peck, 2006). However, there are challenges in these items when serving the child patrons. For example, librarians struggling at the balance of getting what the children need, and what the children want when providing homework help (Mediavilla, 2001); some children are too obsessed on the computer game, and occupied the computer center of the library the entire day (Osborne, 2008). Under insufficient human sources, librarians had little time on providing all kinds of services and solving those problems on children. What's more, some libraries even fail to dedicate a corresponding percentage if their resources to support children (Sullivan, 2005). According to Hatt (1976), the higher the accessibility of the resource is, the bigger the chance the user will use. Waples, Berelson, Bradshaw, and Franklyn (1940) also said that the collection's availability and usability would affect how users read. In order not to affect the reading of children and to support their information need development, it's important to solve the

problem between child patrons and the librarians.

There were different kinds of researches investigating these problems by providing different kinds of instruments. For example, 曾娉妍、蘇桂美、陳麗娟、黃志龍（2004） designed a set of courses to improve the library information literacy of children. However, most of these solutions didn't contain the element of interaction. The interaction has been the important element that exists in the library activities of children since they were in the preschool age (Becker, 2012). This can help they use the library in a familiar context. What's more, according to Texas State Library and Archives Commission (2001), the interaction between the librarian and the student can even improve the students' intellectual ability. Therefore, to better enhancing child patrons' library experience and to reduce the librarians' business pressure, this research proposes that by using robots to serve in the public libraries may solve these problems. According to Wolk (2008) and Bond (2009), library is a place that children learn literacy of choosing books they prefer and a place for language development. The robot that can interact with children can not only be the one that accompany children, but also assist them to have better library experience without obstacles. What's more it can still reserve the value that library have to the children.

2.3 Robots and libraries

2.3.1 Development of robot technology

The past few years has witnessed a significant and rapid development of robotics. According to Takayama, Ju, and Nass (2008), the motivation of creating robots is that people expect the robot can help people to work. Hence, the work that was dirty, dangerous and dull was the main area robots did in the past. From simple technical tasks to interactive activities, robots now are capable of interacting with people, and people are enabled to make extensive use of them to assist life. The typical social robot has human-like shape and multi-sensors. It can achieve non-verbal communications such as expressions in gestures, eye contact, and other social behaviors that simulates and assists human users' conversing and other tasks. For instance, home service robots provide people convenience by having features such as cooking, being a companion, providing home security, and children's teaching assistant at home (Khan, 1998; Roy et al., 2000); mental commit robots which is designed to interact with people and to make them feel emotional attachment to the robots can even sense a user's touch, recognize a limited amount of speech, expresses a small set of vocal utterances, and can move its head (Kidd, 2006). Robots of variety have well-defined physical manifestations to exhibit physical movements and autonomously interact within people's personal spaces (Norman, 2004).

Therefore, according to the technology today, it's possible to design a kind of robot that serves in the public library to assist child patrons.

2.3.2 Robots' in libraries

Nowadays the library robots that have been used most in the library is basically the robotic arms or cranes that help the librarians to arrange and search the collection. For example, University of Chicago's new library uses robotic cranes to shelve and retrieve materials. By using this, the library can hold as many as 3.5 million volumes accessible by the computer-controlled robots (Parry, 2011). Some other library robots that are applied are for book guiding service to the users (Hahn, Twidale, Gutierrez & Farivar, 2010). This study intends to investigate the robot that can not only search the collection but also interact and accompany with the child patrons in the library—the social robot. However, only few social robots have been implemented in the library. Here, the study introduced the researches of social library robots that have been designed and implemented in the library so far:

According to Behan & O'Keeffe (2008), the robot "LUCAS" was an autonomous service robotic assistant that served in the library to assist the users. The robot was a guide for users within the library to locate their specific textbooks. A complete autonomous system had been implemented, which allowed for simple user

interaction to initiate functionality and was described specifically in terms of its implemented localization system and its human–robot interaction system.

Also, Mikawa, Morimoto & Tanaka (2010) designed a librarian robot which had the basic functions as a librarian. The robot was able to say greeting properly to the user as a receptionist. Considering that most users in the library encountered the problem that they didn't know the current location or the books' location, the robot could talk with the user by natural language, searched bibliographical information from the database of the university library through the Internet depending on requests from a user, and showed the search results to the user on a display.

What's more, besides the general preference for the robot as an appropriate agent to provide service to all users, Lin, Yueh, Wu & Fu (2014) designed a robot called "Book Smile" which could provide resource-locating services to children in the library. Because Book Smile was made for children, it was developed as a toy-like character as tall as the average the 9-10 years old children. Equipped with localization system, Book Smile was able to recognize its location and knew the resources' location after receiving the user's request.

Similar to the library settings, robots have been adopted to museums to assist guidance and navigations to have interaction with people (Burgard et al. 1998;

Nomura, Tasaki, Kanda, Shiomi, & Hagita, 2007; Siegwart et al. 2003; Shiomi et al, 2007). However these previous studies focused on the technological advancement and often suffered small user's data which made the findings suggest little references to understand interactivity between human users and the robots.

2.4 Factors that affect Children and robot interaction

2.4.1 Contextual factors

After having understanding about the robots' development in libraries, it's also important to be aware that when introducing robots in the public library, child patrons are facing the challenge to interact with robots to get library services. Therefore, how child patrons interact with robots needs to be concerned. The success of human and robots' interaction builds in whether robots can satisfy what human needs. In the interaction between human, verbal and non-verbal conversation and body language are the important elements. These elements can help people find similarity, common background, and identify each other in order to construct their social relationship. Also, according to Hargie (2004), the process of interacting is also including "Mediating factors", like personal characteristics (knowledge, motives, personality, attitudes, and emotions) may lead people to place others in categories by stereotypes and act differently, or may trigger extreme emotion so that people swear at others.

When it comes to the library, mediating factors may be translated as the library familiarity and usage etc. In the library, children often take the environment as a study place, and do not use the library resources fully （曾雪娥，1993）. This phenomenon make children gradually get unfamiliar with the library and also made the usage of library decreased. In order to solve the problems, school librarians start to design library instruction courses to improve student's library information literacy abilities and the rate of library usage. Harmer (1959) investigated the effect of library instruction courses, and found out that the reading behaviors of students improved after that. Other researches also support this finding that after students taking the courses, the rate of students' library usage increased and their attitude to libraries also improved (Lance, 1994; Schon, 1984).

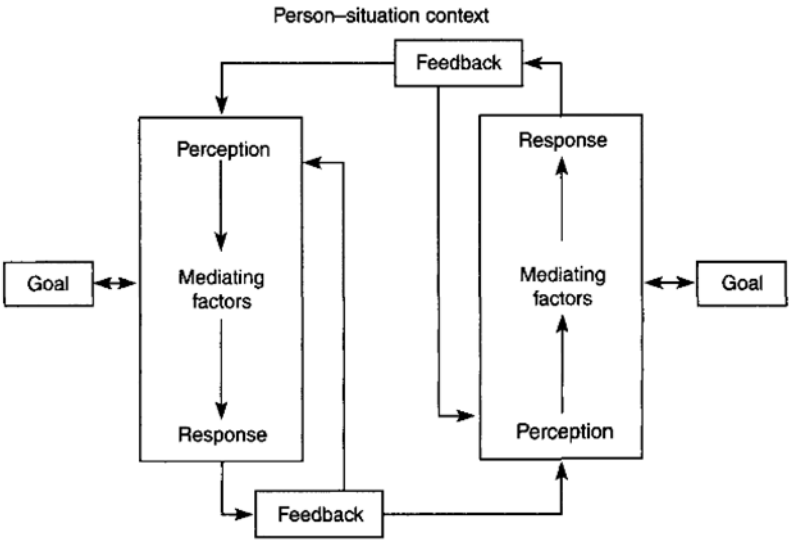


Fig. 1 Person-situation context (Hargie, 2004)

When comparing to the human and robot interaction, the human will transform the former interaction experience (human to human) to robots, like expecting robots to identify who the person is, to have the conversation naturally (Kanda, Hirano, Eaton, and Ishiguro, 2004). There are several researches investigating factors that may affect the interaction between children and robots:

2.4.2 Users' age and gender

Some researchers think that users' age has influence on HRI. For example, Shibata, Wada, and Tanie (2004) discovered that younger people had more favorable impressions of robots than older people. Scopelliti, Giuliani, and Fornara (2005) did the research in Rome and found out that basically, young people had a strong familiarity with technology and they scored higher on "positive feelings" than the other age groups. To the young people, home service robots were humanlike entities to interact with in leisure situations; almost all of them would like to have a speaking robot, mainly with a young voice, and the possibility to personalize its aspect, which would be in general amusing. On the other hand, elderly people were the most frightened at the prospect of having a robot at home, and they tried to ward off their anxiety by attributing to the robot features that abled to reduce the impact with the machine: small size, slow motion, feminine voice, and executing collaborative tasks.

Also, Scopelliti, Giuliani, D'Amico, and Fornara (2004) found that although technology could be useful, older people showed a slight mistrust towards machines that were likely to be unsafe to some extent. Adults seemed to be by far the least homogeneous group in expressing ideas, preferences, attitudes and emotional responses to the possibility of having a robot at home. A substantial percentage of them were highly characterized in terms of "absence of preferences" as to their physical features and type of human-robot interaction. In addition, they showed mid-point scores on attitude and emotional dimensions extrapolated from factor analyses. They probably considered a home service robot as a device which was too futuristic to spend time in thinking about. However, part of them shared with young people a more friendly view of such a device, even if the majority of them would prefer to have complete control over it. Gender and educational level differences were shown to be far less important. What's more, when interacting with a robot in the exhibition, results showed that younger visitors felt more positively less anxious than older visitors, while gender played no significant in perception of robots' friendliness, effectiveness, interest and anxiety (Nomura et al, 2007).

If looking more closely about the attitude children having to robots in young people, basically, when children were in the age from 8 to 14, their preference of robots' appearance and social attraction was similar （董芳武，2013）. Also, children

felt less nervous when interacting with robots than adults. And children were more interested in robots and often felt that robots were friendly to them than others (Nomura et al., 2009). What's more, the feeling children had to robots was positive. They wanted the robot could be their best friends and accompanied them. In Kanda, Hirano, Eaton & Ishiguro (2004)'s research, they found out that over 80% of children would approach robots at first, yet the like and the interaction degree children had to robots would decrease progressively with time went by.

From the studies of children and robots' interaction, robots played the role as teachers, companions or mediators for children (Kanda et al., 2004; Robin, Dautenhahn, Boekhorst, and Billard, 2005). Most of the empirical research of children and robots focus on educational robots. Educational robots are basically assisting users to learn, and to give users the chance to practice and instant feedback (Fagin, B., & Laurence, M., 2003). This kind of robots can also help the user to keep their learning motivation, and improve their learning achievement. Also, children expected robots to be their servant (26.5%) or companion (26.5%) (Lin et al., 2009). This reflects that robots embedding certain service and with function of interactive companion is preferred by children. On the contrary, Nomura, Kanda, Suzuki, and Kato (2009) investigated Japanese about their feeling to robots, the result showed that elder people in Japan may accept assistive robot at home more than younger people.

This kind of difference may because of the culture background. No matter what, these researches showed that the age factor did have difference in HRI.

Also, there are researches think that the gender have some differences. According to Nomura et al. (2008), men who have negative and anxiety feeling to robots, will interact with robots in certain distance and don't want to stay too close; women who have same feeling as men won't behave like what men do, but will not show too much personal feeling to robots. And Mutlu, Osman, Forlizzi, Hodgins, and Kiesler (2006) found out that women were more influenced by the characteristics of the robot comparing with men. However, the findings are not consistent. For example, Siegel, Breazeal, and Norton (2009)'s research result showed that users evaluated a robot of the opposite gender more positively than a same-gender robot; they also behaved more positively to robots with the opposite gender. On the other hand, Eyssel, Kuchenbrandt, Bobinger, Ruiter, and Hegel (2012)'s participants perceived a same-gender robot more positive and psychologically close than the opposite-gender robot. Also, Schermerhorn, Scheutz, and Crowell (2008) found out that male users perceived a robot as more human-like compared to female users.

2.4.3 The robots' appearance

What's more, the appearance of robots will affect how children feel. For example, people may misunderstand what features and characters the robot have because of its appearance, and this may even affect the interaction between human and people (Coradeschi et al., 2006; Syrdal et al., 2009). For instance, people may guessed that, human-like robots with arms that can carry items are more complicate than animal-like robots, and robots that smile to people are tender and kind (Syrdal et al., 2009).

According to Nejat et al. (2009)' s study, interactive robots were classified into two types: (1) animal or creature-like, and (2) human-like. The former has not only animal appearance but also behave like animals; the other has more humanlike appearance and actions. However, to the human-like robot, Mori's research discovered the "Uncanny Valley". This uncanny valley Mori mentions will make people's emotional responses become increasingly positive as the robots' appearance and actions more humanlike. However, as people's response getting higher, the human-like degree of robots' appearance may reached to a point that make people feel the robot looks too scary or uncanny (Mori, 1970). This theory was verified by 董芳武（2013） that the results of the attitude children had to the human-like robot did

showed the curve of uncanny valley. Other research showed that people showed greater HRI acceptance and felt psychologically closer to the robot when robot and participants shared the same gender. Moreover, participants even anthropomorphized a system more strongly when it used a same-gender, but human-like voice (Eyssel et al., 2012).

This kind of misunderstanding to robots will make people interact with robots in incorrect way, and even let people have negative feeling on the HRI. According the research, the negative attitude people have to robots, will affect whether they want robots to serve at home or not (Nomura, Kanda, Suzuki, Yamada, and Kato, 2009). What's more, the posture that robots displayed would affect how people behave. When the robot displayed a less approachable posture (its arms were straight, pointing down and slightly to the side), people did stay in longer distance comparing to the posture that was approachable (its arms opened as showing welcome sign) (Ham et al., 2012).

There's the research about the preference of robot appearance of fifth-grade children. They found out that the character-like robot (or cartoon-like robot) was the most popularoption (41%), which is popular than humanoid among children. Also, children prefer the robots' appearance with "cute" element, no matter its shape is

cartoon character -like (such as PAPERO)or animal-like(such as AIBO) (Lin, Liu, Chang & Yeh, 2009). Although the research didn't mention much about the cute element, it may be assumed as the robot with round shape or abstract facial features from the features that both PAPERO and AIBO had. What's more, their expectation about the robots' abilities is higher than what robots can do now. They hope robots can cope with anything they want them to do, such as do the children's own duties. This is because that children think the robot are stronger and smarter than they are, and have multi-abilities (Lin et al., 2009).

However, according to 董芳武（2013）, the children do have certain robot appearance preference. This situation happened when considering the gender of children. The boys tended to accept the machine-like robot more than the girl; the girls preferred the human-like robot significantly.

From these results, we can assume that people are still not completely accepted robots about their social feature, and don't think that robots can have interaction as how people do. To summarize, Table 1 concluded the factors that will make HRI better or worse from the previous studies.

Table 1 Factors that affect HRI

	HRI better	No differences	HRI worse
Users' age	Younger people		Older people
Users' gender		Men/Women	
The robots' appearance	Human-like type** Approachable posture		Animal/Creature-like Less approachable posture

**Human-like type may cause "Uncanny Valley"

2.5 The personal space

When people are having interaction with other people, people will send message in several ways to let others understand the purpose. For example, age, gender, and culture background will affect the interaction process, like when discussing the older people, in their presence, with a relative rather than addressing them directly; women, comparing with men will interact at closer interpersonal distances and make greater use of eye-contact. What's more, in culture factors, the power distance may appear due to the amount of respect and deference displayed by those in different positions on status hierarchy. These factors will affect other factors while people constructing their common background through conversation.

Space matters in this interacting process while people naturally stay in certain distance with others. Spatial arrangements determine what people say, how they say it, and even whether it's necessary to say anything at all. The space between two people

can determine the duration of an interaction and its emotional tenor. People will use distance to tell other people what he or she thinks about them and what he or she thinks about the current situation (Reeves and Nass, 1996). Hall (1966) thought that people would change their personal space according to different time, place, relationship, and goal; he even used this phenomenon to set four kinds of personal space range. In his definition, intimate space only allow one's lover or close family to enter, and in this space, people do hugs and kisses. Personal space is the distance that friends and couples stay in public area. When someone enters one's personal space, one may feel uncomfortable and even start to protect oneself. Commercial or social activity often form social space, it can make two people having conversation without too much pressure. Public space is hard to let two people start their conversation. Therefore, when one is trying to let others stay in public space, it means that one doesn't want to interact with others.

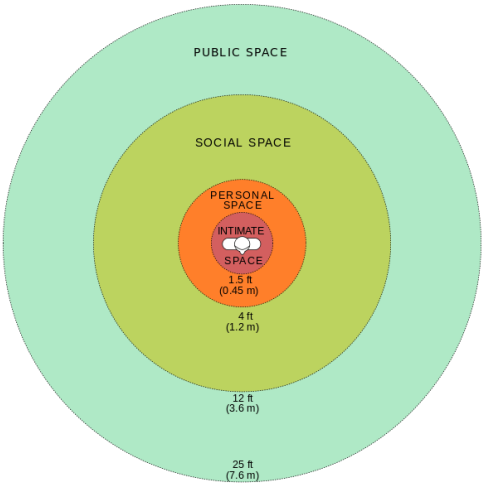


Fig. 2 Four kinds of personal space range (Hall, 1966)

However, the personal space that Edward defined is the average distance that people often stay in all kinds of situation. With different culture, people will behave in different distance. Basically, western countries' people are having more close relationship and shorter personal distance; eastern countries' people are more self-center and more care about people's common background or experience（周麗芳等人，2005）.

When approaching robots or being approached by robots, most people prefer to stay in the distance that are compatible with those expected for normal social interactions between humans. Also, the *Media Equation theory* suggested that the way in which people interact with technology resembles the way in which humans interact with other humans (Reeves & Nass, 1996). This kind of phenomenon also exists in

the situation that technology has the appearance of a social entity, such as a social robot (MacDorman, 2006). In addition, the design of machines sometimes makes the image of human face showed on the machine which can make people behave and interact differently comparing with mechanical-type appearance machines. According to Reeves & Nass (1996), the close faces showed on the machine, were evaluated more intensely than the faces that seemed far away which mean that people would pay more attention and use more recognition memory on the closer image. This result had showed that people performed similar or identical reactions to the machine with human face and human.

However, there are still some of the people perceived the extreme emotion such as threatening or intimate, when they are having interaction with robots (Walters et al., 2005). Some people might refuse to have interaction with robots, or felt offended when asked about their social reaction to the computer afterwards (Reeves & Nass, 1996). According to Walters et al. (2005), the more proactive a person judged him/herself, the longer the human-to-robot approach distances measured. And Ham et al. (2012) found out that participants under high cognitive load approached the robot closer when its posture communicated approachableness than when its posture communicated less approachableness. Also, the factor—emotion which affects the HRI not only exists in human, but also robots. The personal space that human keeps

when interacting with the angry robot is much bigger than the space with normal robot no matter in what kinds of interaction statuses (human approaches to the robot, or the robot approaches human)(Banik et al., 2013). What's more according to Banik et al. (2013), the child (aged 6-18) tend to keep bigger personal space than the young people (aged 19-30) and middle-aged people (aged 31-55) because of children's lack of robots' familiarity.

Overall, Walters et al. (2005) found out that the approach distance to the robot for the majority of people was within the expected ranges for comparable human social space, corresponding to either the personal or intimate space, just as the range Hall (1966) did. However, there had some differences in the situation. It said that there was difference between the distance human approach to robots and robots approach to human. When it comes to the robot approaching human, the distance is longer than the former one.

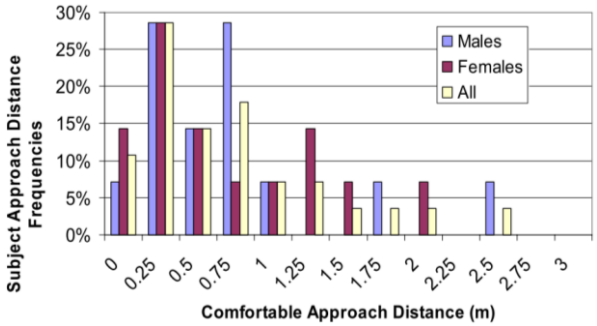


Fig. 3 Distances when human approaching the robot (Walters et al., 2005)

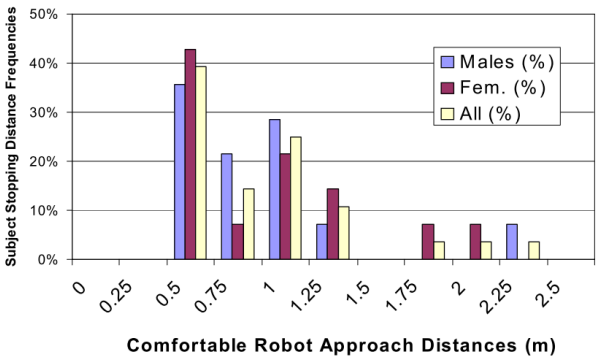


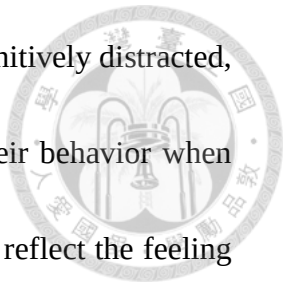
Fig. 4 Distances when the robot approaching human (Walters et al., 2005)

Furthermore, Balasuriya, Watanabe and Pallegedara (2007) researched about how to use the data of human's height, human's familiarity to robots and the robots' appearance to construct a determination system of adaptive personal space that based on adaptive neural fuzzy inference system (ANFIS). However, the research focused on the subject whose height is between161-185cm, but not the height of children. Also, the experiment context is about human approaching to the robot and the robot approaching to the human these two conditions, but not library which may trigger different kinds of interactive motivation.

2.6 Summary

The child patron is one of the major user groups in the public library. They are used to be accompanied by adults or librarians when using the services in the library. Also, due to some obstacles, like lack of library information literacy and physical limits, child patrons often need others' assistance to get the library services. However, sometimes librarians are struggling at meeting the needs of all users in one time. To enhance the child patrons' library experience and to assist librarians' work, it's possible that by introducing robots to serve in the public library can solve the problem.

Before introducing the robot, it's important to know how child patrons feel about robots and how they behave to robots. According to the current researches, there're several factors, like users' age, gender, culture background, and the robots' appearance that will affect the HRI process. What's more, when people are interacting with other people, the attitude people have to others will reflect directly to the distance they stay in (personal space). And this phenomenon also happened in the interaction people have with the robot. If the one which is interacting with people tries to invade this space, not only the interaction will be badly affected but also make people start to protect his/herself.



However, according to Ham et al. (2012), when people are cognitively distracted, their behavior to robots is of a social nature and comparable to their behavior when responding to other humans, which means that human intuition can reflect the feeling people have to robots more correct than people think carefully before behave. Some of the researches above are not using children's direct responses, like movement and face expression to analysis the results, like Nomura et al. (2009) and Lin et al. (2009). These two researches use questionnaires to investigate how children feel about robots and their preference of robots' appearance without real interaction between children and robots. Also, the research that Fagin & Laurence did in 2003 didn't use the direct response of participants. They used the data that students made in the computer to analysis the instant feedback.

What's more, to investigate the behavior to robots, the current study assessed a well-studied (in human-human interaction) behavior: interpersonal distance people keep, though not from other humans but from a robot (Ham et al., 2012). Although the other two researches (Kanda et al., 2004; Robin et al., 2005) used video data analysis (people' direct responses) as their research method, they didn't use the distance between children and robots as one of their research variables. Therefore, this research intends to use child patrons' direct responses and the personal space they keep to investigate the feeling child patrons have to robots in the library context. To

summarize, Table 2 concluded the research method that current researches did to understand the attitude children have to robots.

Table 2 Summary of researches about children and robots

	Research method	**Research result**
Nomura et al., 2009	Questionnaire	Children' attitude
Lin et al., 2009	Questionnaire	Children's robot appearance favor
Fagin & Laurence, 2003	Course data analysis	Children's feedback after interacting with robots
Kanda et al., 2004	Questionnaire & video analysis	The behavior children have to robots
Robin et al., 2005	Video analysis	The role robots played
Banik et al., 2013	Data analysis	The personal space under robots with different emotion
Balasuriya, Watanabe & Pallegedara, 2007	Data analysis	Construct a personal space determination system

3. Methodology

This research examined child patrons' interaction with robots in the library to understand the actual feeling child patrons have to robots. To obtain valid data, a designated experiment was conducted to extract insight from users' actual behaviors instead of reported opinions and impression without actual experience. Also, to better understand how child patrons' behave in different contexts, this research used the factors that discussed in the literature review: users' age, gender, and robots' appearance as variables to see the difference. Quasi-experiment was therefore adopted as the proper research method to approach the context targeted by this research.

Quasi-experiment is a method for researchers to investigate causation. And this research used two-group posttest-only design as the experiment design. This is almost identical to classical experiment except the former one doesn't have a pretest (Neuman, 2002). This research adapted this method to compare two groups of participants when they were taking the task.

3.1 Participants

This study recruited 77 participants from 3rd grade to 6th grade (age 9-12) from an elementary school in Taipei. And the experiments were conducted in the library of this elementary school. The ratio of gender was 34:43 (boy: girl). All participants

participated in the experiments under their free wills and parents' consents. The participants were divided into two groups to interact with robots with human-like appearance and machine-like appearance respectively.

3.2 Instruments and settings

To understand child patrons' feelings and movements in the interaction with the robot, this study used two different kinds of appearance of robots: the human-like robot named "Julia" or "Edward", compared to the machine-like robot named "Book Smile". "Julia" or "Edward" represented the former one, with two hands and a human-like face displayed in the head screen. It could do various postures by its two hands and would wink its eyes while interacting with people. However, in order to perform a book holding task in this experiment, the hands of Julia were fixed in certain position (Fig. 5). "Book Smile" was the later one, with a "Z" shape body and looked like a toy resembling cartoon character. Its mouth-shape shelf enabled people to put the book on it. Therefore, in this experiment, Book Smile was carrying the book by its shelf when performing the task. Furthermore, to restrict two robots in the same condition besides the appearance, both of them were equipped with lasers to detect obstacle and participant's legs which could measure distance data independently without external assistance.

In order to understand if children's development of gender roles affected their interaction with the robots, What's more, because to the child in the 3rd-6th grade, their gender awareness is gradually higher than before, the study designed different gender role of the robots to the experiment （黃鳳娟，2013）four different design of robots were provided. To present the Julia with the human-like girly appearance and female voice; Edward with the human-like boyish appearance and Book Smile with the machine-like neutral appearance with female and male voice. The speech speed and content are set as the same across four designs.

Fig. 5 Julia

Fig. 6 Edward

Fig. 7 Book Smile

3.3 Experiment design

3.3.1 Variable

During the experiment, the users' personal space would be measured and the movement of the participant would be observed through the task. First, the users' personal space would be measured according to the distance that the participant kept when he/she having interaction with the robot during the task by the robot laser. If the participant failed to have the interaction with the robot, the distance would be measured at the point he/she gave up completing the task in the end. What's more, because of the robots' design, the users' personal space that the participant kept would be measured differently in order to best reflect the same concept that the users' personal space was the distance that from the participants to the edge of the robot's body (Fig. 8 and 9). Also, the action of the participant would be observed during the entire experiment process by the video camera to see what kinds of facial expressions, movements, or other body languages the participant had to the robot.

Fig. 8 The measurement of personal space between the participant and Julia/Edward

Fig. 9 The measurement of personal space between the participant and Book Smile

3.3.2 Scenario

The research designed one task in this experiment. Participants will be required by the robot to respond to its utterances or conduct certain actions. The content of the task was selected from common library services that child patrons had been experienced in the public library—books recommending.

In the task, the participant would first be given an orientation of the task by the experimenter in the library. After the orientation finished, the participant would be asked to wait for a minute. After a period of time, the robot would appear in the experiment area with a book carrying in its hands/ on its shelf. The robot would first approach the participant while introducing itself at the same time and stop at certain place where was 1.5 meter away from the participant was (the maximum distance that interaction happened according to Hall(1966)). The robot would then introduce the book it carried, and recommend the participant to take a look at it. After 3-5 minutes of interaction between the participant and the robot, the task was finished. In order to observe the nature behavior the participant had to the robot, during the task, the participant would not be restricted to do certain actions. He/she was free to do any emotion or action according to their feelings (it was therefore no task failure in this experiment).

From the literature review part, the researchers thought that different genders' robots may affect the HRI. According to Eyssel et al. (2012), people showed greater HRI acceptance and felt psychologically closer to the robot when robot and participants shared the same gender. However, in Siegel, Breazeal, and Norton (2009)'s research, the results showed that users evaluated a robot of the opposite gender more positively than a same-gender robot; they also behave more positively to

robots with opposite gender. In this study, the Julia robot is colored pink and the Book Smile robot is colored yellow. Also, both robots' voice was more female-like. The participants may assume the robot's gender as the female. To investigate how the robot's gender affected the interaction between the participant and the robot, after the former experiment ended the study asked the participants to interact with the robot that with boy features again with the same process as the first one.

In the second experiment, the participant that interacted with Julia at first would be assigned to the context of the robot "Edward", and the participant that interacted with Book Smile at first would be assigned to the context of the robot "Book Smile" with boy voice.

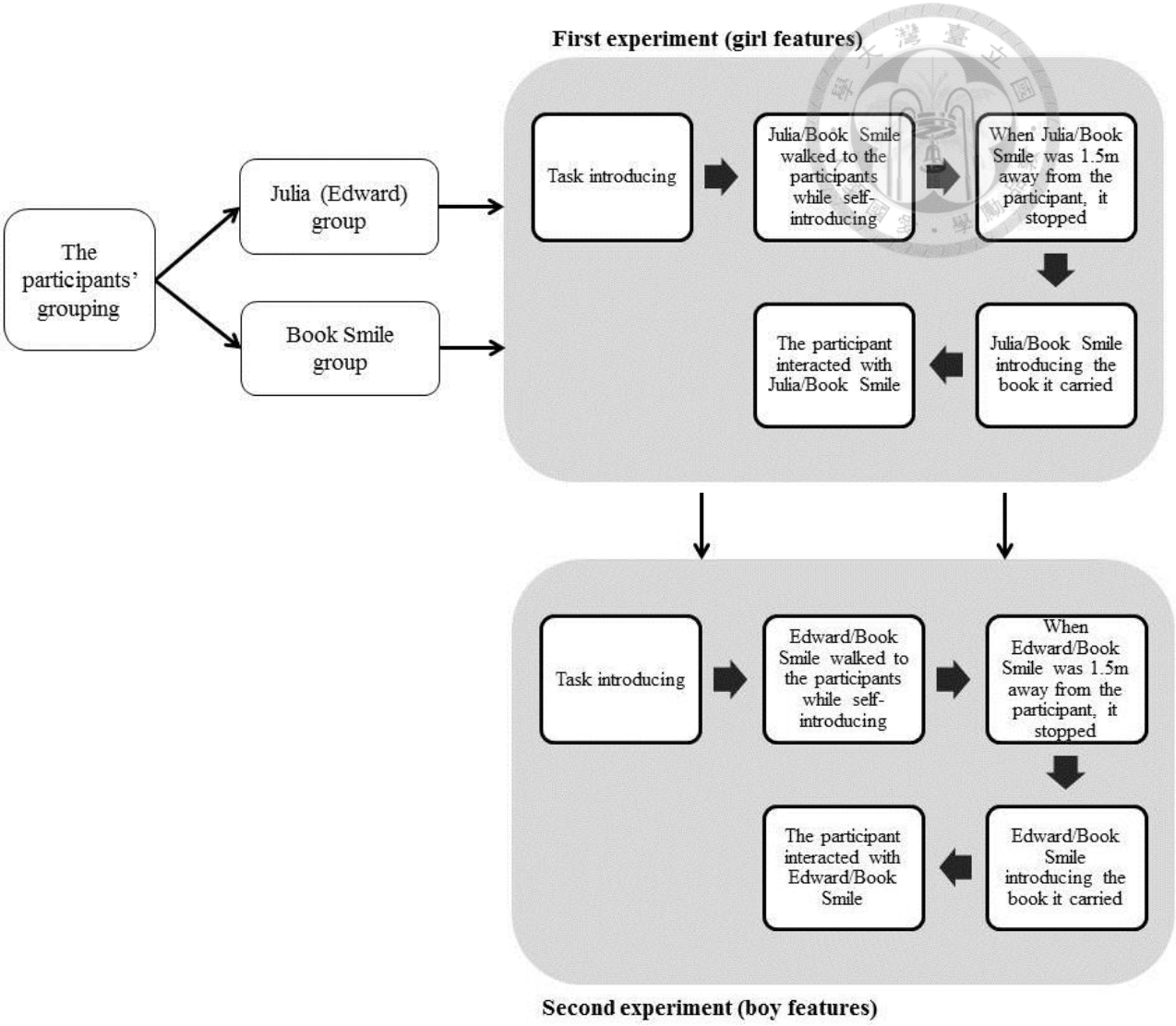


Fig. 10 The experiment procedure

3.4 Questionnaire

The study designed the paper-based questionnaire after the experiment task to investigate three parts: the participants' attitude to robots, the participants' robot appearance preference, and the participants' basic information. The 11 questions in attitude part was revised from the robot anxiety scale (RAS) and Negative attitudes toward robots scale (NARS) from Nomura, Kanda, Suzuki, and Kato (2008)'s research. What's more, the questions' sentences were redesigned based on the language the participants used to.

Table 3 Questionnaire's factor analysis

Questions	% of Variance	Cumulative %	Component 1	2	3
4. I feel comforted interacting with the robot in front of other people.	26.95%	26.95%	.83	-.07	.25
2. I feel easy when the robot moves toward me.			.80	.19	.05
1. I feel relax interacting with the robot.			.73	.27	.14
8. If the robot had emotions, I would be able to make friends with them.			.64	.24	-.07
7. I feel comforted being with robots that have emotions.			.61	.26	.05
3. I would read the book that the robot recommended.	16.92%	43.87%	.17	.70	-.11
9. The robot talked about irrelevant things in the middle of the interaction.			.29	.69	.05
5. I am concerned that the robot would be a bad influence on me.			.19	.67	.29
10. The robot might not understand too many conversation topics.	15.40%	59.27%	.15	.11	.79
11. I don't know how to respond when the robot talks to me.			.26	-.22	.72
6. I feel that if I depend on the robot too much, something bad might happen.			-.28	.38	.69

The questionnaire's factor analysis shown that the questions can be divided into three parts: the participants' comfort to robots (component 1), the feeling of the library task (component 2), and the negative attitude to robots (component 3). Also, the questionnaire asked about the robot appearance preference which is measured by asking the participant to choose which kinds of robot's features they like in semantic differential scale. And in the last, the basic information asked the participant to answer their grade and age. The answer is designed in Likert 6 scale to investigate the participants' thinking. The higher the score, the better agreement of what the participant thought was (appendix).

The study used Cronbach's α to test the reliability of this questionnaire's internal inconsistency. According to DeVellis (1991), Nunnally (1978), and 榮泰生（2009）, the questionnaire has high reliability when the value of Cronbach's α is over 0.70. This study's result showed that the value of Cronbach's α is 0.77 which represented that the questionnaire had high reliability to test the participants' attitude toward robots.

3.5 Data analysis

In this study, the action that participants do in the experiment will be observed and reported by descriptive statistics. The difference of the users' personal space of each experiment under different contexts will be compared and examined by T-test. Also, the relationship between each variable will be compared and statistically examined by correlation analysis.

To analysis the questionnaire, RAS and NARS from Nomura, Kanda, Suzuki and Kato (2008)'s research would be the reference basis. Also, in order to better compare all the scores, the negative questions' scores in the questionnaire would be reversed to compute the data (only scores but not the questions). For example, the original six-point scale: (1) strongly disagree; (2) disagree; (3) a little disagree; (4) a little agree; (5) agree; (6) strongly agree, would be transformed as: (1) strongly agree; (2) agree; (3) a little agree; (4) a little disagree; (5) disagree; (6) strongly disagree. When analyzing the questionnaire in three parts (the participants' comfort to robots, the feeling of the library task, and the negative attitude to robots), the scores of the participants on each part would be computed by adding the scores of all items included in that part, with some negative items having reverted computation.

4. Results and discussion

This study recruited 77 participants (34 boys and 43 girls) in the first experiment, and the distribution of the participants' age was shown at Table 4. However, one of the participants refused to interact with the robot, the study only had 76 participants to produce the distance data. Due to the personal and academic reasons, some participants were absence in the second experiment. There were 49 participants (19 boys and 30 girls) in the second experiment.

Table 4 Distribution of the participants' age

	Frequency	**Percent**
5^{th} -6^{th} grade	41	53.2%
3^{rd} -4^{th} grade	36	46.8%
Total	77	100.0%

The average personal space of the 76 participants was 0.56m (min=0, max=1.87). And the attitude that the participants had to the robot was positive.

Table 5 Participants' attitude to robot

	N	**Min**	**Max**	**Mean**
The participants' comfort to robots	76	1.20	6.00	4.29
The feeling of the task	76	1.67	6.00	4.76
Positive attitude to robots	76	1.00	6.00	3.93

4.1 Participants' personal space and attitude to robots with different robots' appearances

4.1.1 Personal space in facing different robots' appearances

To investigate whether the robot's appearance will affect the personal space the participants' keep from the robot. The study used the data from human-like robot (Julia) group and machine-like robot (Book Smile) group to run independent groups of T-test (each participant only interact with one of the robot) to see the difference.

Table 6 T-test of robots' appearance & the personal space

Appearance	**N**	**Mean**	**S.D.**	***t***
Julia	36	.35	.54	-3.25**
Book Smile	40	.75	.54	

**Result is significant at 0.01 level (2-tailed)

The descriptive statistics shown that when the participant interacted with the human-like robot, Julia, the average personal space was 0.35m, which was the level of intimate space according to Hall (1966) (distance < 0.45m). On the other hand, the participant who interacted with the machine-like robot, Book Smile, performed the personal space in 0.75m. Although the later one was relatively far than the former one, the personal space that the participant shown was still in the level of personal space (distance < 1.2m) which represented that the participant willing to interact with the robot from social space to the closer space—personal space.

Also, the result shown that the T-test value was significant ($p = 0.00 < \alpha = 0.01$).Therefore, there were significant differences existed in the personal space between the human-like robot (Julia) group and the machine-like robot (Book Smile) group. The personal space the participant kept when interacting with Julia was significantly closer than the other group.

To avoid Julia and Book Smile's girl-like features affect the results, the study used the data from human-like robot (Edward) group and machine-like robot (Book Smile-boy features) group to run independent groups of T-test (each participant only interact with one of the robot) again to see the difference.

Table 7 T-test of robots' appearance & the personal space (boy features)

Appearance	**N**	**Mean**	**S.D.**	***t***
Edward	24	.25	.54	-4.57**
Book Smile	25	.78	.54	

**Result is significant at 0.01 level (2-tailed)

The result was also significant. What's more, when conducting the experiment, the ways that most participants took the book were different between two groups. The participant would approach the human-like robot (Julia) to take the book, and stayed in front of the robot to read the content. However, the participant would backward immediately after taking the book from the machine-like robot (Book Smile), and read the content in certain distance away from the robot.

Interestingly, some participants in the human-like robot (Julia) group said that they felt nervous when standing in front of the robot. One of the participants even refused to take the experiment when the robot appeared. However, this participant would will to interact with the robot in the second experiment when having the experimenter to accompany. On the other hand, in the machine-like robot (Book Smile) group, fewer participants had the same nervous feeling to the robot. The reason may be the wink of the Julia's eyes that parts of the participants said that they felt like being watched when reading. Also some even thought that the winking eyes were scary. This may refer to the theory that Mori (1970) discovered—the "Uncanny Valley" that the people may feel the robot looking too scary or uncanny when the robot's features are too anthropomorphized.

What's more, during the experiment, participants showed different reading behaviors when interacting with the machine-like robot and the human-like robot. For participants that facing the human-like robot (Julia/Edward), they tended to read the book on the shelf of the robot, only few of them took the book away from it and read on their own hands. And for the participants that interacting with the machine-like robot (Book Smile), they would pick the book up to read. Although this phenomenon may due to the design of the robot, there still some participants read the book on the machine-like robot (Book Smile). Looking more closely to the reading of participants,

most of the participants read the book page by page (61.22%). Only 28.57% of the participants browse the book. There still had 5 participants (3 from the machine-like robot group and 2 from the human-like robot group) refused to take the book to read from the robot. Most of these participants felt nervous about the process, some even thought that the robot was scary. If divided the participants by age, there were 50.00% of the 5^{th}-6^{th} grade student and 69.23% of the 3^{rd}-4^{th} grade student read the book page by page. And 37.50% of the 5^{th}-6^{th} grade student and 19.23% of the 3^{rd}-4^{th} grade student browsed the book. The differences that the higher grade students read page by page less and browse the book more than the lower grade students may due to that the book's topic didn't fit their interest. Some of the 5^{th}-6^{th} grade students said that they thought the book didn't attract them. According to Wood (2007), the children in 5^{th}-6^{th} grade preferred reading the book that contains certain topic. Hence, the robot book recommending service should pay more attention to the book' topic choosing for the older children.

Fig. 11 The reading behavior of the participant when interacting with the human-like robot

Fig. 12 The reading behavior of the participant when interacting with the machine-like robot

4.1.2 Attitude for different robots' appearances

(1) Participants' feeling for robots with different appearances

To investigate whether the robot's appearance will affect the attitude the participants' had to the robot. The study used the questionnaire data from human-like robot (Julia) group and machine-like robot (Book Smile) group to run independent groups of T-test (each participant only interact with one of the robot) to see the difference. Different groups of the participants' comfort attitude to the robot were

shown in Table 8.

Table 8 Participants' comfort for robots with different appearances

	Appearance	**N**	**Mean**	**S.D.**	***t***
I feel relax interacting with the robot.	Julia	37	4.14	1.48	-1.35
	Book Smile	40	4.55	1.22	
I feel easy when the robot moves toward me.	Julia	37	3.97	1.40	-0.25
	Book Smile	40	4.05	1.36	
I feel comforted interacting with the robot in front of other people.	Julia	37	4.16	1.48	-0.36
	Book Smile	40	4.28	1.30	
I feel comforted being with robots that have emotions.	Julia	37	4.59	1.61	1.17
	Book Smile	40	4.15	1.72	
If the robot had emotions, I would be able to make friends with them.	Julia	36	4.44	1.68	-0.02
	Book Smile	40	4.45	1.36	

The results showed that the comfort attitude that participants had were positive (almost all of the scores' M>4). The study may assume that the participants feel comfort and relax when interacting with robots. Among all the questions, the Julia group scored the "I feel comforted being with robots that have emotions" highest (M=4.59). Also, the participants scored the lowest when asking the comfortable degree when the robot moves toward the participants. This may because that the participants didn't know they were going to interact with the robot before the experiment and felt confused. However, there was no significant difference between two groups of the participants.

Table 9 Participants' feeling of the library task for robots with different appearances

	Appearance	**N**	**Mean**	**S.D.**	***t***
I would read the book that the robot recommended.	Julia	36	4.67	1.22	-0.03
	Book Smile	40	4.68	1.56	
I am concerned that the robot would be a bad influence on me.*	Julia	37	5.05	1.20	1.44
	Book Smile	40	4.60	1.55	
The robot talked about irrelevant things in the middle of the interaction.*	Julia	37	4.81	1.47	0.33
	Book Smile	40	4.70	1.49	

*Negative questions' scores were reversed

In the feeling of the library task part, the results were positive which showed that the participants were willing to get book recommending service from robots. Also, the scores of the feeling of the task were higher than the comfort attitude. The participants didn't feel the robot would have bad influence on them, also they feel the robot's conversation contents were relevant. However, there was still no significant difference between two groups of the participants in the feeling of the task.

Table 10 Participants' negative attitude for robots with different appearances

	Appearance	**N**	**Mean**	**S.D.**	***t***
I feel that if I depend on the robot too much, something bad might happen.*	Julia	37	4.05	1.60	0.01
	Book Smile	39	4.05	1.34	
The robot might not understand too many conversation topics.*	Julia	37	4.49	1.64	-0.61
	Book Smile	40	4.70	1.45	
I don't know how to respond when the robot talks to me.*	Julia	37	3.05	1.73	-0.72
	Book Smile	40	3.33	1.58	

*Negative questions' scores were reversed

In the negative attitude aspect, most participants scored over 4 in each questions. They thought the robots could understand different kinds of conversation topics, and won't have bad influence on them. However, the participants gave the lower score in the last question—I don't know how to respond when the robot talks to me.

Overall, from three aspects in the questionnaire, the data showed that the attitude the participants' had to the robot had no big differences between the Julia group and the Book Smile group. This may be that besides the human-like and machine-like differences, the two robots both had the elements that the children preferred. According to Lin at al. (2009), children prefer the robots' appearance with "cute" element (which may assume as the robot with round shape or abstract facial features from the features that both PAPERO and AIBO had), no matter its shape is human-like or animal-like. With Julia and Book Smile robot used cartoon-like and "cute" elements in their design, it was therefore the attitude results showed no difference in two groups.

(2) Participants' robot appearance preference after facing different robots' appearances

In the questionnaire, the study also investigated the participants' preference of the robot's appearance. The results showed that there were no differences between two groups (Julia and Book Smile). Most participants preferred the robot with no human-like body, arms, monitor, and emotion. Interestingly, the scores in the factor of facial features showed significant difference, the Julia group (*M=3.86, S.D. =2.03*) preferred the robot with facial features more than the Book Smile group (*M=2.83, S.D. =1.75*). This may because of the robot features the participants interacted in the experiment: the Julia group tended to choose the feature that fit the Julia most.

Table 11 Participants' robot appearance preference after interacting with robots of different appearances

	Group	**N**	**Mean**	**S.D.**	***t***
Human-like body	Julia	36	2.53	1.80	-0.99
	Book Smile	40	2.93	1.72	
Arms	Julia	36	4.58	2.01	0.48
	Book Smile	40	4.38	1.78	
Monitor	Julia	36	4.08	2.23	1.27
	Book Smile	40	3.45	2.11	
Facial features	Julia	36	3.89	2.03	2.46*
	Book Smile	40	2.83	1.75	
Emotion	Julia	37	4.32	2.21	-0.88
	Book Smile	40	4.72	1.74	

*Result is significant at 0.05 level (2-tailed)

Overall, the participants preferred the machine-like figure and human-like features. According to Lin, Liu, Chang & Yeh (2009), the 5th-grade children liked the character-like robot (or cartoon-like robot) most. The reason that this result happened may be that the picture that represented the machine-like robot in the questionnaire was more like the stereotype of the robot that the participants thought than the human-like robot's picture.

4.2 Participants' genders and interaction with robots

4.2.1 Boys' and girls' personal space in interacting with robots

(1) Boys' and girls' interaction with female robots

To investigate whether the participants' gender will affect the personal space the participants' keep from the robot (girl features). The study used the data from boy and girl groups to run independent groups of T-test (each participant only interact with one of the robot) to see the difference.

Table 12 T-test of boys' and girls' personal space in interacting with female robots

Gender	**N**	**Mean**	**S.D.**	***t***
Boy	34	.72	.66	2.25*
Girl	42	.43	.45	

*Result is significant at 0.05 level (2-tailed)

The data showed that when the boy interacted with the robot (girl features), the average personal space was 0.72m, which was the level of personal space (distance<1.2m). On the other hand, the girl who interacted with the robot (girl

features) performed the personal space in 0.43m, which was in the range of intimate space (distance<0.45m), and was closer than the former one. It may be said that the girl was more willing to interact with the robot (girl features) than the boy.

The results of the t-test were significant ($p = 0.03 < \alpha = 0.05$). Hence, there were differences existed in the personal space between the boy and girl groups. The personal space the girl kept when interacting with the robot (girl features) was significantly closer than the boy. This could also translate as the girl regarded the robot (girl features) as their close friends or family more than the boy according to Hall (1966). The boy took the robot (girl features) as normal friends than the girl.

What's more, there were different situations when looking at the personal space that both participants interacted with Julia or Book Smile (girl features).

Table 13 T-test of boys' and girls' personal space in interacting with Julia

Gender	**N**	**Mean**	**S.D.**	***t***
Boy	16	.52	.63	1.75
Girl	20	.21	.41	

When interacting with Julia, the girl tended to interact with the robot in closer distance than the boy (not significant). The girl interacted with Julia in intimate space (distance<0.45m); the boy was in the personal space (distance<1.2m). This may related to "uncanny valley" (Mori, 1970) and the result that Schermerhorn, Scheutz, and Crowell (2008) found out that male users perceived a robot as more human-like compared to female users. The boy may perceive Julia as too human-like robot that

stayed a farther distance than the girl.

Table 14 T-test of boys' and girls' personal space in interacting with Book Smile (girl features)

Gender	N	Mean	S.D.	*t*
Boy	18	.90	.65	1.58
Girl	22	.62	.40	

When the participants interacted with Book Smile (girl features), the girl also stayed in closer distance with the robot (girl features) than the boy (not significant). However, both boy and girl interacted with Book Smile (girl features) in the personal space (distance<1.2m) different with the situation that interacted with Julia.

(2) Boys' and girls' interaction with male robots

To investigate whether the participants' gender will affect the personal space the participants' keep from the robot (boy features). The study used the data from boy and girl groups to run independent groups of T-test (each participant only interact with one of the robot) to see the difference.

Table 15 T-test of boys' and girls' personal space in interacting with male robots

Gender	N	Mean	S.D.	*t*
Boy	19	.49	.46	-0.33
Girl	30	.54	.51	

The data showed that there were no significant differences between the boy and the girl's personal space. The average personal space that the boy interacted with the robot (boy features) was 0.49m, which was the level of personal space (distance<1.2m). On the other hand, the girl who interacted with the robot (girl

features) performed the personal space in 0.54m, which was same in the range of personal space (distance<1.2m), and was farther than the former one. Both groups took the robot (boy features) as normal friends. And it may be said that the boy was more willing to interact with the robot (boy features) than the girl.

Comparing the results that the participants interacting with the robots with boy features and girl features, the boys were more close to the robot with boy features and the girls were more close to the robot with girl features. Just as what Eyssel et al. (2012) said, participants perceived a same-gender robot more positive and psychologically close than the opposite-gender robot. What's more, Schermerhorn, et al. (2008) found out that male users perceived a robot as more human-like compared to female users. This may be the reason that the average personal space that the boy stayed with the same-gender robot (0.49m) was farther than the girl with the same-gender robot (0.43m).

4.2.2 Boys' and girls' attitudes toward robots

(1) Boys' and girls' feelings for the interaction with robots

To investigate whether the participants' gender will affect the attitude the participants' had to the robot. The study used the questionnaire data from the boy and girl groups to run independent groups of T-test (each participant only interact with one of the robot) to see the difference. Different groups of the participants' comfort

attitude to the robot were shown in below.

Table 16 Boys' and girls' comfort for the interaction with robots

	Gender	**N**	**Mean**	**S.D.**	***t***
I feel relax interacting with the robot.	Boy	34	4.18	1.42	0.96
	Girl	43	4.49	1.30	
I feel easy when the robot moves toward me.	Boy	34	3.79	1.27	0.71
	Girl	43	4.19	1.44	
I feel comforted interacting with the robot in front of other people.	Boy	34	4.00	1.37	0.50
	Girl	43	4.40	1.38	
I feel comforted being with robots that have emotions.	Boy	34	4.18	1.62	0.59
	Girl	43	4.51	1.71	
If the robot had emotions, I would be able to make friends with them.	Boy	34	4.12	1.63	0.10
	Girl	42	4.71	1.37	

The result showed that the comfort attitude that participants had was positive (almost all of the scores' M>4). Also, from the score can see that the girl had better comfort attitude to the robots than the boy (the girl's scores were higher than the boy). What's more, although both gender were willing to make friend with a robot of emotions, the results showed that the girl (*M=4.71, S.D. =1.37*) were more willing than the boy (*M=4.12, S.D. =1.63*). However, there was no significant difference between two groups of the participants in the comfort attitude part.

Table 17 Boys' and girls' feeling of the library task for the interaction with robots

	Gender	N	Mean	S.D.	*t*
I would read the book that the robot recommended.	Boy	33	4.33	1.43	-1.87
	Girl	43	4.93	1.33	
I am concerned that the robot would be a bad influence on me.*	Boy	34	4.65	1.45	-0.95
	Girl	43	4.95	1.36	
The robot talked about irrelevant things in the middle of the interaction. *	Boy	34	4.15	1.54	-3.44**
	Girl	43	5.23	1.23	

*Negative questions' scores were reversed

**Result is significant at 0.01 level (2-tailed)

In the feeling of the library task, the girl was more positive than the boy to get book recommending service from robots. What's more, there is significant difference in the third question of the feeling of the task part. During the conversation, the girl (*M=5.23, S.D. =1.54*) thought that the robot won't talk irrelevant things more than the boy (*M=4.15, S.D. =1.23*).

Table 18 Boys' and girls' negative attitude for the interaction with robots

	Gender	N	Mean	S.D.	*t*
I feel that if I depend on the robot too much, something bad might happen.**	Boy	34	3.91	1.53	-0.76
	Girl	42	4.17	1.41	
The robot might not understand too many conversation topics.**	Boy	34	4.12	1.86	-2.38*
	Girl	43	4.98	1.12	
I don't know how to respond when the robot talks to me.**	Boy	34	3.35	1.57	-0.75
	Girl	43	3.07	1.71	

*Result is significant at 0.05 level (2-tailed)

**Negative questions' scores were reversed

In the negative attitude, the first and the third questions had no significant difference. In the second question showed that the girl (*M=4.98, S.D. =1.12*) was more positive than the boy (*M=4.12, S.D. =1.86*) on the conversation topic of the robots' understanding.

(2) Boys' and girls' preference toward robots with different appearance

From the gender aspect to see the difference of the preference of the robot appearances, the results showed no differences in the human-like appearance, arms, and emotion parts.

Table 19 Boys' and girls' preference toward robots with different appearance

	Group	**N**	**Mean**	**S.D.**	***t***
Human-like appearance	Boy	34	2.44	1.62	-1.33
	Girl	42	2.98	1.84	
Arms	Boy	34	4.85	1.74	1.60
	Girl	42	4.17	1.95	
Monitor	Boy	34	2.71	2.02	-4.14**
	Girl	42	4.60	1.94	
Facial features	Boy	34	2.71	1.95	-2.60*
	Girl	42	3.83	1.82	
Emotion	Boy	34	4.26	2.11	-1.06
	Girl	43	4.74	1.87	

*Result is significant at 0.05 level (2-tailed)

**Result is significant at 0.01 level (2-tailed)

The participants liked the robot with no human-like appearance, arms, and emotion. However, in the monitor and facial features parts, there were significant

differences between the boy and the girl: the girl liked the robot with monitor (*M=4.60, S.D. =1.94*) and facial features (*M=3.83, S.D. =1.82*) more than the boy felt about the monitor (*M=2.71, S.D. =2.02*) and the facial features (*M=2.71, S.D. =1.95*).

According to Nomura et al. (2008), men who have negative and anxiety feeling to robots, will interact with robots in certain distance and don't want to stay too close; women who have same feeling as men won't behave like what men do, but will not show too much personal feeling to robots. The results showed that the boy had less positive attitude than the girl in all attitude parts. This may be the reason that the boy stayed in farther distance than the girl when interacting with the robot.

4.3 Participants' ages and the interaction with robots

4.3.1 Participants' ages and the personal space in interacting with the robots

To investigate whether the participants' age will affect the personal space the participants' keep from the robot. The study used the data from 5^{th}-6^{th} grade and 3^{rd}-4^{th} grade to run independent groups of T-test (each participant only interacted with one of the robot) to see the difference.

Table 20 T-test of participants' personal space in interacting with the robots

Age	**N**	**Mean**	**S.D.**	***t***
5^{th}-6^{th} grade	41	.59	.59	0.55
3^{rd}-4^{th} grade	35	.52	.55	

The data showed that the average personal spaces between the 5^{th}-6^{th} grade's participants (0.59m) and the 3^{rd}-4^{th} grade's participants (0.52m) were in the same range. Both of the groups were in the personal space (distance < 1.2m), but not the intimate space (distance < 0.45m).

The results of the t-test were not significant ($p = 0.58 > \alpha = 0.05$). Hence, there were no differences existed in the personal space between the older (5^{th}-6^{th} graders) and the younger participants (3^{rd}-4^{th} graders). From this result could see that the age factor didn't affect the change of the personal space.

4.3.2 Participants' ages and their attitude toward the robots

(1) Participants' feeling of the interaction across different age group

To investigate whether the participants' age will affect the attitude the participants' had to the robot. The study used the questionnaire data from the 5^{th}-6^{th} grade's participants and the 3^{rd}-4^{th} grade's participants groups to run independent groups of T-test (each participant only interacted with one of the robot) to see the difference. Different age groups of the participants' comfort attitude to the robot were shown in below.

Table 21 Participants' comfort of the interaction across different age group

	Age	**N**	**Mean**	**S.D.**	***t***
I feel relax interacting with the robot.	5^{th}-6^{th} grade	41	4.27	1.36	-0.57
	3^{rd}-4^{th} grade	36	4.44	1.36	
I feel easy when the robot moves toward me.	5^{th}-6^{th} grade	41	3.98	1.24	-0.25
	3^{rd}-4^{th} grade	36	4.06	1.53	
I feel comforted interacting with the robot in front of other people.	5^{th}-6^{th} grade	41	4.05	1.26	-1.17
	3^{rd}-4^{th} grade	36	4.42	1.50	
I feel comforted being with robots that have emotions.	5^{th}-6^{th} grade	41	4.41	1.70	0.28
	3^{rd}-4^{th} grade	36	4.31	1.65	
If the robot had emotions, I would be able to make friends with them.	5^{th}-6^{th} grade	40	4.08	1.56	-2.33*
	3^{rd}-4^{th} grade	36	4.86	1.36	

*Result is significant at 0.05 level (2-tailed)

Although in the comfort attitude part, the top four questions had no significant difference, the scores that these participants gave in the two groups were almost all over 4. This can be related to the results that Nomura et al. (2009) found: children are

more interested in robots and often feel that robots are friendly to them than others .Also, in the fifth question showed that the 3rd-4th grade (*M=4.98, S.D. =1.12*) was more positive than the 5th-6th grade (*M=4.12, S.D. =1.86*) to be able to make friends with robots had emotions. This result echoed what Shibata, Wada, and Tanie (2004) had discovered that the the younger people had more favorable impressions of robots than the older people.

Table 22 Participants' feeling of the library task of the interaction across different age group

	Age	**N**	**Mean**	**S.D.**	***t***
I would read the book that the robot recommended.	5th-6th grade	41	4.95	1.20	1.89
	3rd-4th grade	35	4.34	1.55	
I am concerned that the robot would be a bad influence on me.*	5th-6th grade	41	5.07	1.19	1.69
	3rd-4th grade	36	4.53	1.58	
The robot talked about irrelevant things in the middle of the interaction.*	5th-6th grade	41	4.73	1.48	-0.14
	3rd-4th grade	36	4.78	1.48	

*Negative questions' scores were reversed

Although the feeling of the library task was positive to get book recommending service from robots. The results showed that there was no significant difference between two groups of the participants, which means that the attitude the 5th-6th grade and the 3rd-4th grade's participants had was close.

Table 23 Participants' negative attitude of the interaction across different age group

	Age	**N**	**Mean**	**S.D.**	***t***
I feel that if I depend on the robot too much, something bad might happen.*	5th-6th grade	40	4.45	1.34	2.60*
	3rd-4th grade	36	3.61	1.48	
The robot might not understand too many conversation topics.*	5th-6th grade	41	4.66	1.28	0.36
	3rd-4th grade	36	4.53	1.81	
I don't know how to respond when the robot talks to me.*	5th-6th grade	41	3.29	1.75	0.55
	3rd-4th grade	36	3.08	1.54	

*Negative questions' scores were reversed

*Result is significant at 0.05 level (2-tailed)

In the negative attitude, the last two questions had no significant difference. However, in the first question showed that the 5th-6th grade (*M=4.45, S.D. =1.34*) was more positive than the 3rd-4th grade (*M=3.61, S.D. =1.48*) to feel that the dependence on the robot won't let the bad things happen.

(2) Participants' ages and preference toward robots with different appearance

There were no significant differences in human-like appearance, monitor, and emotion parts from age aspect. However, the 3rd-4th grade's participant liked the robot with arms (*M=5.06, S.D. =1.39*) much more than the other group (*M=3.98, S.D. =2.10*).

Table 24 Participants' ages and preference toward robots with different appearance

	Group	**N**	**Mean**	**S.D.**	***t***
Human-like appearance	5th-6th grade	41	2.51	1.61	-1.21
	3rd-4th grade	35	3.00	1.89	
Arms	5th-6th grade	41	3.98	2.10	-2.68*
	3rd-4th grade	35	5.06	1.39	
Monitor	5th-6th grade	41	3.80	2.16	0.24
	3rd-4th grade	35	3.69	2.23	
Facial features	5th-6th grade	41	3.39	2.08	0.30
	3rd-4th grade	35	3.26	1.80	
Emotion	5th-6th grade	41	4.39	2.08	-0.67
	3rd-4th grade	36	4.69	1.86	

*Result is significant at 0.05 level (2-tailed)

From the literature could see that most of the researches did the age differences in a larger age range than this study, such as the adult vs. the children, and the elderly vs. the teenager. In this study, the age range was limited because the study intended to do a research about children's feeling and behavior to the robot. That may be the reason that made the age differences in the personal space were not significant in this study. This also echoed what 董芳武（2013）said, when children were in the age from 8 to 14, their preference of robots' appearance and social attraction was similar.

4.4 Summary

4.4.1 The participants' personal space when interacting with robots in different contexts

To summarize, both gender and robot appearance would affect the personal space that the participants kept from the robot. Participants would interact with human-like robot in the intimate space ($m<0.45$) despite of the robot's gender. On the other hand, when interacting, the participant would stay in a farther space (personal space, $m<1.2$) with machine-like robot. What's more, when it talks to the gender, the results support what Eyssel et al. (2012) said, participants perceived a same-gender robot more positive and psychologically close than the opposite-gender robot. Boys and girls interacted with robots in closer space when robots are same genders as them.

According to Hall (1966), the phenomenon above could be explained as the participant that interacted with the human-like robot took the robot as one's lover or close family and also thought the experiment area (library) as a private space. On the other hand, the one that interacted with machine-like robot took the robot as their friends and couples, and thought the library as a public area.

What's more, in this experiment the closest personal space that the participants kept was 0m which was performed by 9 participants. These participants' information is showed in Table 25.

Table 25 Participants that interacted with the robot in the closest personal space

	Age		**Robot type**		**Gender**	
	3rd-4th	**5th-6th**	**Julia**	**Book Smile**	**Boy**	**Girl**
Total (people)	6	3	9	0	3	6

From the result can assume that the features that the one may interact with the robot in closer space are: younger age, girl, and interacting with the robot of human-like type. On the other hand, the one that interacted with the robot in the farthest personal space was the 5th grade boy that interacted with Book Smile.

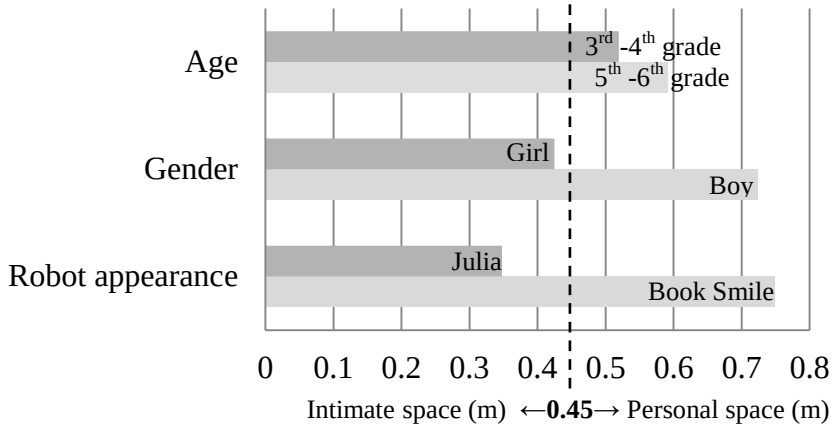


Fig. 13 The personal space under different contexts

4.4.2 The participants' attitude when interacting with robots in different contexts

In the attitude part, overall the participants had positive attitude to the robots. However, the two factors: robots' appearance and the participants' age didn't affect the attitude the participants had to the robots.

From the gender aspect, the girl made the better scores than the boy on the comfort, task, and the positive attitude part. Especially in the task part, the scores between the boy and the girl showed significant differences. Girls were more willing

to read the book that the robot recommended them than boys. This situation confirms the results that Eyssel et al. (2012) discovered: participants perceived a same-gender robot more positive and psychologically close than the opposite-gender robot.

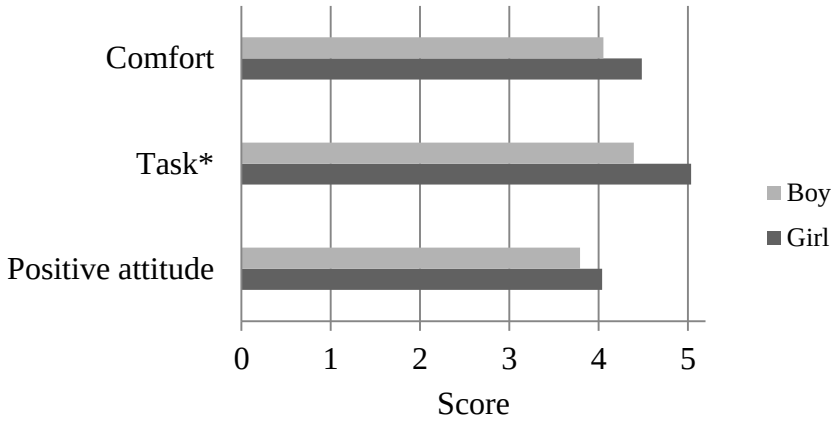


Fig. 14 Participants of different genders' attitude to robots

In the robot appearance preference part, overall, the participants preferred the robot in machine-like figure and human-like features: with arms, monitor, facial features, and emotions. However, the participants' preference on monitor and facial features was more neutral than defining them to certain side. Moreover, the results showed significant differences, if add different factors in the result analysis. For example, the participants who interacted with the human-like robot, preferred the robot had facial features more than the ones who interacted with the machine-like robot. Also, the girl liked the robot with monitor and facial features more than the boy liked the robot with monitor and facial features.

5. Conclusion

This study has discussed the personal space and the attitude in interaction between child patrons and robots under different context (the robot with human-like appearance and the robot with machine-like appearance). It was established by analyzing the distance, video, and questionnaire data of the child patrons' attitude and the behaviors.

The results showed that the child patrons are willing to use the service that the robot recommending the book for them. Also, they are willing to read the book from the robot. From the results, the robots' appearances do affect the interaction between the child patrons and the robot. When the participant interacted with the human-like robot (Julia/Edward), they tended to interact in intimate space; on the other hand, the participant who interacted with the machine-like robot, Book Smile would prefer to interact in personal space. However, although the participants who interacted with the human-like robot stayed in closer distance, some of the participants still felt the winking eyes of the human-like robot were scary.

Moreover, there are gender differences in the child patrons' interaction: the personal space that the girl interacted with the robot (intimate space) in was closer than the boy (personal space) when they were interacting with the girl-like robot. When it comes to the boy-like robot, despite all participants interacting in the personal

space, boys would stay in closer space than girls. And the attitude that the girl had to the robot was also more positive than the boy. That is to say that the robots' appearance and the child patrons' gender factor would affect the personal space that the child patrons and the robot interacted with in.

In the attitude part, this study discovered that the child patrons had positive feeling to the robot. They felt comfortable interacting with the robot and were willing to read the book that the robot recommended to them. Also, the study found out that both child patrons' age and robot appearances two factors won't affect the attitude the child patrons had to the robot. However, the gender factor did affect the attitude the child patrons had to the robot. The child patrons were more willing to interact with the robot and be friends of them when the robot was the same gender as them.

What's more, when talking about the robot appearance's preference, most child patrons like the robot with machine-like figure and with human-like features: arms, monitor, facial features, and emotions. When adding different factors into the analysis, the human-like features' elements changed. However, the machine-like figure was still the child patron's favorite no matter what kinds of elements adding into the analysis.

The study was distinct from previous studies of HRI space (Banik et al., 2013; Balasuriya, Watanabe & Pallegedara, 2007) in context- specific and methodology. First, it examined the personal space that the child patrons performed in the library

which is a place that exchanging all kinds of information and emotions with users. Therefore, this study not only can help to better understand the child patrons' feeling to the robot service in the library, but also provide the results of how robots interact with child patrons under all kinds of information and emotions' exchanging. Second, this study's sample size was big (77 participants) that allowed all kinds of comparisons in sufficient number of samples and reduced sampling errors more.

Finally, it should be noted that the study was limited by the participants' background. In this study, the participants were all the students from Taiwan, where the students may feel less familiar than other countries that develop robots maturely. As Bartneck et al. (2005) said, the cultural background had a significant influence on people's attitude to robots. Hence, the opinions and the personal space of the robot may be different when the experiment is conducted in other countries. Yet, the study's results are still the good references when the library is considering introducing the robot service in the future.

Here, this study started from Taiwan to establish one aspect of the child patrons' personal space in the library with the robot. The results showed that the gender and the robots' appearance do affect the personal space; also the gender would affect the attitude that the child patrons have. This may be the reference for the library to conduct the robot service and its content.

References

周麗芳、鄭伯壎、陳靜慧、任金剛、許金田（2005）。華人高階管理者網絡中的特殊連帶與人際　情感：深層心理契合與正式工作關係的效果。*本土心理學研究*，*23*，201-257。

陳幗眉、洪福財（2001）。*兒童發展與輔導*。臺北市：五南。

曾娉妍、蘇桂美、陳麗娟、黃志龍（2004）。資訊素養融入國小五年級自然科教學之研究。*圖書館學與資訊科學*，*30*（1），41-54。

曾淑賢（2001）。兒童線上公用目錄查詢系統檢索行為之研究。*國立中央圖書館臺灣分館館刊*，*7*(2)，13-33。

曾雪娥（1993）。四十年來的中小學圖書館。*中國圖書館學學會報*，*51*，51-59。

黃鳳娟（2013）。*國小中高年級學童性別意識與圖像性別表徵之調查研究*（未出版之碩士論文)。國立新竹教育大學藝術與設計學系藝術教育與創作碩士班，新竹市。

董芳武（2013）。兒童對人形機器人之感知與評價研究。*設計學報*，*18*（3），23-39。

詹棟樑（1994）。*兒童人類學——兒童發展*。臺北市：五南。

圖書館法（2001年01月17日）。

榮泰生（2009）。*AMOS與研究方法*。臺北市：五南。

臺北市立圖書館（2012）。*解讀 2012 臺北人閱讀行為及借閱排行榜*。2013 年 8 月 30 日。取自：http://www.tpml.edu.tw/public/Attachment/31281449162.pdf

鄭雪玫（1991）。*兒童圖書館理論／實務*。臺北市：臺灣學生。

蘇國榮（2013）。*淺談兒童室的規劃：以花師圖書館兒童室為例*。2013 年 9 月 13 日。取自：http://www.wenkiang.com.tw/su6.htm

Agosto, D.E. (2007). Why do teens use libraries? Results of a public library use survey. *Public Libraries*, *46*(3), 55–62.

Balasuriya, J.C., Watanabe, K., and Pallegedara, A. (2007). ANFIS based active personal space for autonomous robots in ubiquitous environments. In *Proceedings of the 2007 International Conference on Industrial and Information Systems*, 523-528.

Banik, S. C., Gupta, A. K. S., Habib, M. K., & Mousumi, R. N. (2013). Determination of active personal space based on emotion when interacting with a service robot. *International Journal of Advanced Robotic Systems*, *10*, 1-7.

Becker, K. (2012). 24 Hours in the children's section: An observational study at the public library. *Early Childhood Education Journal*, *40*(2), 107-114.

Behan, J. & O'Keeffe, D. (2008). The development of an autonomous service robot. Implementation: "Lucas"—The library assistant robot. Intelligent Service Robotics, 1(1), 73-89.

Benton Foundation (1996). *Buildings, books and bytes: Libraries and communities in the digital age*. Retrieved September 2, 2013, from: https://www.ideals.illinois.edu/bitstream/handle/2142/8130/librarytrendsv46i1o_opt.pdf?sequence=1

Burgard, W., Cremers, A.B., Fox, D. Hähnel, D., Lakemeyer, G., Schulz, D., Steiner, W. &Thrun, S. (1998). The Interactive Museum Tour-Guide Robot. *Proceedings of The National Conference On Artificial Intelligence*, 11-18.

Bond, M. A. & Wasik, B. A. (2009). Conversation stations: Promoting language development in young children. *Early Childhood Education Journal*, *36*(6), 467-473.

Coradeschi, S., Ishiguro, H., Asada, M., Shapiro, S., Theilscher, M., Breazeal, C., Mataric, M., & Ishida, H. (2006). Human-inspired robots. *IEEE Intelligent Systems*, *21*(4), 74.

DeVellis, R. F. (1991). *Scale Development Theory and Applications*. London: SAGE.

Eyssel, F., Kuchenbrandt, D., Bobinger, S., Ruiter, L. de and Hegel, F. (2012). If you sound like me, you must be more human: On the interplay of robot and user features on human-robot acceptance and anthropomorphism. In *Proc. 7th ACM/IEEE Conf. Human-Robot Interaction (HRI 2012)*, 125-126.

Fagin, B., Laurence, M. (2003). Measuring the effectiveness of robots in teaching computer science. *SIGCSE Bull*, *35*, 307-311.

Hahn, J., Twidale, M., Gutierrez, A., & Farivar, R. (2010). Methods for applied mobile digital library research: A framework for extensible wayfinding systems. *The Reference Librarian*, *52*(1/2), 106–116.

Hall, E. T. (1966). *The hidden dimension: Man's use of space in public and private*. London: The Bodley Head Ltd.

Ham, J., Esch, Mirjam van, Limpens,Y., Pee, Jente de, Cabibihan, J.-J., Ge, Shuzhi Sam. (2012). The automaticity of social behavior towards robots: The influence of cognitive load on interpersonal distance to approachable versus less approachable robots. *Social Robotics Lecture Notes in Computer Science*, *7621*, 15-25.

Hargie, O. (2004). *Skilled interpersonal communication: research, theory and practice*. New York: Routledge.

Harmer, W. R. (1959). *The effect of a library training program on summer loss or gain in reading abilities*. Ph.D. dissertation, University of Minnesota.

Hatt, F. (1976). *The Rading Process: A framework for analysis and description*. London: Clive Bingley.

Kanda, T., Hirano, T., Eaton, D., & Ishiguro, H. (2004). Interactive robots as social partners and peer tutors for children: A field trial. *Human–Computer Interaction*, *19*, 61–84.

Khan, Z. (1998). Attitudes towards intelligent service robots. *NADA KTH Technical Report, Stockholm*.

Kidd, C. D. (2006). A sociable robot to encourage social interaction among the elderly. In *Proceedings of the 2006 IEEE International Conference on Robotics & Automation*, 3972-3976.

Kohlberg, L. (1966). A cognitive-developmental analysis of children's sex- role concepts and attitudes. In E. E. Maccody (Ed.), *The development of sex differences.* Stanford, CA: Stanford University Press.

Lance, K.C. (1994). The impact of school library media centers on academic achievement. *School Library Media Quarterly*, *22*(3), 167-172.

Lin, W., Yueh, H.-P., Wu, H.-Y., & Fu, L.-C. (2014). Developing a service robot in children's library: A design-based research approach. *Journal of the American Society for Information Science and Technology, 65*(2), 290-301.

Lin, Y.C., Liu, T.C., Chang, M. & Yeh, S. P. (2009). Exploring children's perceptions of the robots. In *Proceedings of the 4th International Conference on E-Learning and Games: Learning by Playing. Game-based Education System Design and Development*, 512-517

MacDorman, K.F. (2006). Subjective ratings of robot video clips for human likeness, familiarity and eeriness: An exploration of the uncanny valley. In *Proceedings of Conference on Cognitive Science Workshop on Android Science*, 26–29.

Mediavilla, C. (2001). *Creating the full-service homework center in your library.* Chicago: American Library Association.

Mikawa, M, Morimoto, Y. & Tanaka, K. (2010). Guidance method using laser pointer and gestures for librarian robot. *RO-MAN, 2010 IEEE*, 373-378.

Mori, M. (1970). Bukimi no tani (The Uncanny Valley). *Energy, 7*(4), 33-35.

Mutlu, B. & Forlizzi, J. (2008). Robots in organizations: The role of workflow, social, and environmental factors in human-robot interaction. In *Proceedings of 2008 3rd ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, 287-294.

Mutlu, B., Osman, S., Forlizzi, J., Hodgins, J., Kiesler, S. (2006). Perceptions of Asimo: Task structure and user attributes as elements of human-robot interaction design. In *Proceedings of the 15th IEEE Symposium on Robot and Human Interactive*, 351–352.

Nejat, G. Sun,Y., & Nies, M. (2009). Assistive robots in health care setting. *Home Health Care Management & Practice, 21*(3), 177-187.

Neuman, W. L. (2002). *Social research methods: Qualitative and quantitative approaches*. Boston, MA : Allyn and Bacon.

Norman, D. A. (2004). *Emotional design: Why we love (or hate) everyday things*. New York: Basic Books.

Nomura, T, Suzuki, T., Kanda, T., Han, J., Shin, N., Burje, J., & Kato, K. (2008). What people assume about humanoid and animal-type robots: Cross-cultural analysis between Japan, Korea, and the USA. *International Journal of Humanoid Robotics, 5*, 25-46.

Nomura, T., Kanda, T., Suzuki, T., and Kato, K. (2008). Prediction of human behavior in human-robot interaction using psychological scales for anxiety and negative attitudes toward robots. *IEEE Transactions on robotics*, *24*(2), 442-451.

Nomura, T., Kanda, T., Suzuki, T., and Kato, K. (2009). Age differences and images of robots: Social survey in Japan. *Interaction Studies*, *10*(3), 374-391.

Nomura, T., Kanda, T., Suzuki, T., Yamada, S., and Kato, K. (2009). Influences of Concerns toward Emotional Interaction into Social Acceptability of Robots. In *Proceedings of the 4th ACM/IEEE international conference on Human robot interaction*, 231-232.

Nomura, T., Tasaki, T., Kanda, T. Shiomi, M. & Hagita, N. (2007). Questionnaire-Based Social Research on Opinions of Japanese Visitors for Communication Robots at an Exhibition. *AI and Society*, *21*(1-2), 167-183.

Nunnally, J. C. (1978). *Psychometric Theory* (2nd ed.). New York: McGraw-Hill.

Osborne, V. (2008). Engaging kids where kids are at: The Eltham library project. *APLIS*, *21*(4), 178-181.

Raqi, S. A. & Zainab, A. N. (2008). Observing strategies used by children when selecting books to browse, read or borrow. *Journal of Educational Media & Library Sciences*, *45*(4), 483-503.

Parry, M. (2011). A high-tech library keeps books at faculty fingertips--With robot help. *Chronicle of Higher Education*, *57*(42). Retrieved December 18, 2013, from: https://chronicle.com/article/A-High-Tech-Library-Keeps/128370/

Peck, P. (2006). *Crash course in children's services*. London: Westport, Conn.

Reeves, B. & Nass, C. (1996). *The media equation: how people treat computers, televisions, and new media like real people and places*. New York: Cambridge University Press.

Robins, B., Dautenhahn, K., Boekhorst, R. T. & Billard, A. (2005). Robotic assistants in therapy and education of children with autism: can a small humanoid robot help encourage social interaction skills? *Journal of Universal Access in the Information Society, 4(2)*, 105-120.

Roy, N., Baltus, G., Fox, D., Gemperle, F., Goetz, J., Hirsch, T., Margaritis, D., Montemerlo, M., Pineau, J., Schulte, J., Thrun, S. (2000). Toward personal service robots for the elderly. In *Proceedings of the Workshop on Interactive Robotics and Entertainment (WIRE)*.

Schermerhorn, P., Scheutz, M., Crowell, C. (2008). Robot social presence and gender: Do females view robots differently than males? In *Proceedings of the 3rd ACM/IEEE Conference on Human-Robot Interaction*, 263–270.

Schon, I. (1984). The effects of a special school library program on elementary students' library use and attitudes. *School Library Media Quarterly, 12*(3), 227-231.

Scopelliti, M., Giuliani, M. V., D'Amico, A. M., and Fornara, F. (2004). If I had a robot at home. Peoples' representation of domestic robots. In Keates, S., Clarkson, J., Langdon, P., and Robinson, P. (Eds.), *Designing a more inclusive world* (pp. 257-266). New York: Springer.

Scopelliti, M., Giuliani, M. V., and Fornara, F. (2005). Robots in a domestic setting: A psychological approach. Universal Access in Information Society, 4, 146-155.

Shaffer, D. R. (2009). *Social and Personality Development (6th ed.)*. Belmont, CA: Wadsworth.

Shibata, T., Wada, K., & Tanie, K. (2004). Subjective evaluation of a seal robot in Brunei. In *Proceedings of 13th IEEE International Workshop on Robot and Human Interactive Communication*, 135-140.

Shiomi, M., Kanda, T., Ishiguro, H. & Hegita N. (2007). *Communication Robots in Real Environments*. In: Matthias Hackel (Eds.) Humanoid Robots: Human-like Machines (pp.567-576),Vienna, Austria: Intech.

Siegel, M., Breazeal, C., Norton, M. I. (2009). Persuasive robotics: The influence of robot gender on human behavior. In *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems*, 2563–2568.

Siegwart, R., Arras, K., Bouabdallah, S., Burnier, D., Froidevaux, G., Greppin, X. Jensen, B., Lorotte, L. M., Meisser, M., Philippsen, R., Piguet, R., Ramel, G., Terrien, G. & Tomatis, N. (2003). Robox at Expo.02: A large-scale installation of personal robots. *Robotics and Autonomous Systems*, *42*, 203–222

Sullivan, M. (2005). *Fundamentals of children's services*. Chicago: American Library Association.

Syrdal, S., Koay, K. L., Walters, M. L.& Dautenhahn, K. (2009).The boy-robot should bark! Children impressions of agent migration into diverse embodiments. In *Proceedings of New Frontiers in Human-Robot Interaction*, 116-121.

Takayama, L., Ju, W., Nass, C. (2008). Beyond Dirty, Dangerous and Dull: What Everyday People Think Robots Should Do. In *Proceedings of 3rd ACM/IEEE International Conference on Human-Robot Interaction*, 25-32.

Texas State Library and Archives Commission (2001). *Texas school libraries: Standards, resources, and students' performance.* Retrieved May 1, 2014, from https://www.tsl.texas.gov/ld/pubs/als/index.html

Tolbert, E. L. (1980). *Counseling for career development* (2nd ed). Boston: Houghton Mifflin.

Walters, M. L., Dautenhahn, K., Boekhorst, R., Koay, K. L., Kaouri, C., Woods, S., Nehaniv, C., Lee, D., and Werry, I. (2005). The influence of subjects' personality traits on personal spatial zones in a human-robot interaction experiment. In *Proceeding of IEEE International Workshop on Robot and Human Interactive Computing (ROMAN).*

Walters, V. (2003). Public library services to children and teens: A research agenda. Library Trends, 51(4), 571-589.

Waples, D, Berelson, B., Bradshaw, and Franklyn, R. (1940). *What reading does to people: A summary of evidence on the social effects of reading and a statement of problems for research.* Chicago: The University of Chicago press.

Wicks, J. (1995). Patterns of reading among teenage boys: The reading habits and book preferences of 13-15 year old boys. *New Library World*, *96*(1122), 10-16.

Wolk, S. (2008). Joy in school. *Educational Leadership, 66*(1), 8-15.

Wood, C. (2007). *Yardsticks: Children in the Classroom Ages 4-14.* Massachusetts: Northeast Foundation for Children.

Young, H. (1983). *The ALA glossary of library and information science*. Chicago: American Library Association.

Appendix: The experiment questionnaire

親愛的小朋友：

下面的問題主要想知道你在剛剛和機器人互動的看法。回答的時候不用緊張，只要依照你自己的想法回答就可以了！這裡沒有標準答案，寫下你心中的答案就可以了。非常謝謝你！

國立臺灣大學圖書資訊學研究所　　指導教授 林維真 博士

研究生 許文馨 敬上

一、基本資料：

1. 我是：○男生　○女生　　2. 我就讀OO國小____年____班

二、對機器人之感受

【填寫說明】你同不同意下面句子說的呢？非常同意的請把６圈起來，同意的請把５圈起來，有一點同意的請把４圈起來，有一點不同意的請把３圈起來，不同意的請把２圈起來，非常不同意的請把１圈起來。

項　目	非常不同意←→非常同意
1. 我對於和機器人互動感到自在	1 2 3 4 5 6
2. 當機器人向我靠近時，我感到自在	1 2 3 4 5 6
3. 我會因為機器人推薦書籍而去讀這本書	1 2 3 4 5 6
4. 我覺得和機器人在大家面前互動時，感到自在	1 2 3 4 5 6
5. 我覺得機器人對我有不好的影響	1 2 3 4 5 6
6. 我覺得太依賴機器人的話，會有不好的事情發生	1 2 3 4 5 6
7. 如果機器人有喜怒哀樂，我感到自在	1 2 3 4 5 6
8. 如果機器人有喜怒哀樂，我願意和機器人做朋友	1 2 3 4 5 6
9. 我覺得機器人會說一些不相關的話	1 2 3 4 5 6
10. 我覺得機器人不能理解太多話題	1 2 3 4 5 6
11. 我不確定要怎麼和機器人相處	1 2 3 4 5 6

三、機器人外觀

【填寫說明】你比較喜歡哪一邊的機器人？請在靠近你比較喜歡的機器人圈圈中打勾。

	喜歡程度	
1. 像機器的 	○ ○ ○ ○ ○ ○	像人的 
2. 沒有手臂 	○ ○ ○ ○ ○ ○	有手臂 
3. 身上沒有螢幕 	○ ○ ○ ○ ○ ○	身上有螢幕 
4. 沒有五官 	○ ○ ○ ○ ○ ○	有五官 
5. 沒有喜怒哀樂 	○ ○ ○ ○ ○ ○	有喜怒哀樂 

———謝謝你！寫完後請交給旁邊的大姐姐！———