國立政治大學資訊管理學系

碩士學位論文

內隱提示如何影響人機互動：結合人格特質和非語言交流之圖書館機器人探討

How Implicit Cues Influence Human-Humanoid Robot Interaction: Combining Personality Traits and Non-verbal Communication for Developing Robot Librarian

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摘要

隨著科技的進步,人形機器人改變了過去提供服務的方式,相較於平面系統,機器人具有類似於人類的外觀,能提供利用其物理特徵,與使用者進行更豐富的互動。機器人可應用於各種生活場域,這種新科技帶給人類更方便的服務。然而目前機器人在實際應用方面仍有許多限制,很少有效使用到人形機器人的物理特徵,為了使機器人服務更廣泛被運用,開發符合使用者期待與滿足任務場域的需求服務,以有效提升使用者與機器人互動意願,儼然已成為目前的重要議題。本研究針對圖書館使用者,探討是否能利用機器人提供之文字訊息與手勢成功塑造機器人的不同個性,並探討機器人個性差異對受測者感受之影響。

本研究首先以受測者訪談了解一般使用者對於機器人的期望,研究結果顯示機器人的語音與手勢為最常被使用的機器人功能。為開發適合應用在圖書館的機器人服務,本研究以非語音溝通方式為主,設計機器人的文字與手勢。設計出提供圖書館服務的機器人。本研究針對學生進行調查,檢驗圖書館機器人提供之非語音表徵,是否能成功塑造機器人的不同個性,研究結果顯示受測者能夠有效辨識機器的人格特質。本研究進一步檢驗不同的機器人特質對使用者與機器人互動之影響。結論指出手勢的使用的確能夠提升使用者的辨識率與使用體驗,研究成果可做為參考架構並開發人形機器人於不同場域的各式服務。

關鍵字: 人形機器人、人機互動、人因工程、機器人個性

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Abstract

With the advancement of science and technology, humanoid robots have greatly changed our daily lives. The usage of a humanoid robot can deliver better services than the conventional information systems, in which a humanoid robot has human-like appearance and can use its physical features to communicate with human operators and resulting in more efficient consequences. However, there are still many limitations in the actual application of robots. In order to make robot services more widely used, the development of services that meet the expectations of users and meet the needs of the task field can effectively enhance the willingness of users to interact with robots. This research is aimed to examine whether the textual cues and gestural cues provided by robots can be used to successfully shape different robot personalities, and explore the effects of robot personality in human humanoid robot interaction.

Three rounds of user study were conducted to explore the impact of the usage of humanoid robots. The qualitative interviews were conducted to collect empirical feedbacks. The results show that voice and gesture functions are the essential components of a humanoid robot to deliver the relevant services. Different robot personality design was developed to further examined the impact of robot personality. The results revealed that the use of gestures can improve the recognition rate and user experience. This research provides an innovative way to develop a robot personality via using non-verbal features. The research findings offer guidance for future research across different task contexts.

Keywords: Humanoid robot, Human-robot interaction, Human factors, Robot personality

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Chapter 1 Introduction

1.1 Background and motivation

Humanoid robots have greatly changed our daily lives. The relevant applications can be found in train stations, shopping malls, and various public places (Hayashi et al., 2007; Satake et al., 2015; Tonkin et al., 2018). For example, in airports, a humanoid robot can act as a front-desk assistant to provide tourist information (Hayashi et al., 2007), guide visitors' directions (Tonkin et al., 2018), or deliver the assistance in different languages (Kennedy et al., 2016). Prior research revealed that humanoid robots can provide better services than the conventional (2D) information systems (Vitale et al., 2018), in which a humanoid robot has human-like appearance and can use its physical features to communicate with human operators, leading to more efficient consequences. For instance, participants tended to share more private information with humanoid robots than information systems (Vitale et al., 2018), suggesting robot usage can increase human likeliness and intimacy with robots.

Most of the existed humanoid robots display information by its own tablet devices or apply voice applications to communicate with human. However, these functions failed to efficiently utilize humanoid robot's physical features (such as eye-contact, heading, gaze, gesture, etc.). In other words, the developers may simply adopt HCI design guidelines to implement humanoid robot applications, which would end up building only a moveable tablet rather than a moveable robot. Although humanoid robot can assist human in a variety of fields, due to the insufficient hardware and software capabilities, there are still numerous limitations of the robot itself. However, potential

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users might have inapplicable expectations of robot's functionalities in assisting the users' routine tasks. It is therefore important to investigate the potential gaps between users' expectations and robot's current capabilities for the purpose of enhancing the overall user experience in human-humanoid robot collaboration (HHRC). Since users' needs and expectations of humanoid robots can vary a lot in different conditions, to develop an appropriate robotic application, identifying users' understandings and exploring their actual usages of (humanoid) robots is critical.

Personality has been identified as an important factor that can improve the human-humanoid robot interaction (Robert, 2018). The Big-Five personality is the most commonly adopted in human robot interaction to improve the interaction quality(Vinciarelli &Mohammadi, 2014). Prior study concluded that people responded differently to robots that have different forms of personality (Salem et al., 2015). In addition, (Craenen et al., 2018) found human operators prefer to work with robots that have similar personalities to them. For example, researchers (Joosse et al., 2013) examined the preference of extroverts and introverts on robots that performed different tasks. The results showed extroverts tended to interact with the extroverted robot rather than the introverted robot. However, these preferences can be significantly varied due to the differences of task contexts (Joosse et al., 2013). In other words, the influences of personality traits in HHRC can be greatly changed in various domains and should be carefully scrutinized.

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There is currently no research dedicated the personality of robots in libraries, so we aim to explore the impact of personality traits to readers by utilizing library service.

Library is an institution to provide diverse information resources. In addition, readers need a quiet place to study in library. The main novelty of the experiments presented in this study is that we combine non-verbal cues and robot personality. To develop appropriate robotic application, we focus on design less-disturbing service via non-verbal behavior.

1.2 Research questions

This study has two research goals. To provide proper robotic service, this study first examined users' expectations of a humanoid robot's services and evaluate the differences between the existed robotic systems and users' expected services, especially in the library contexts. Second, to examine the influences of personality traits in HHRC, different types of personalities will be developed and implemented in the robot librarians and the experimental user study will be conducted to empirically examine users' attitudes and behaviors while interacting with the robot librarians.

Two research questions are examined:

- RQ1: Does non-verbal approach effectively simulate the robot personality traits?
- RQ2: Does robot personality influence the readers' attitude to use the library service?

The experimental design was inspired and guided by the folk model method to explore the general public's attitudes and perceptions of robots and humanoid robots(Wash, 2010; Yao et al., 2017, 2019). The folk model approach has been applied to explore

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people's understandings on how innovative technologies may work in the daily tasks. While describing the experiences in a target system, the participants were asked to sketch their understandings of the system along with appropriate annotations to explain the drawing. For example, prior research applied folk model approach to examine people's knowledge on the online behavioral advertising (Yao et al., 2017) or a Bluetooth beacon system(Yao et al., 2019). A humanoid robot can be seen as an innovative design, in which the general public may have little understanding or experiences on the robot, leading to limited use of robotic services. To identify the users' intentions of humanoid robots, folk model is therefore adopted in this study. Two rounds of qualitative interviews were conducted to collect empirical feedbacks.

This paper is organized as follows. Chapter 2 describes the literature review. Chapter 3 provides the research design and methods. Chapter 4, Chapter 5 and Chapter 6 present the details of first rounds of user studies, including the experimental designs, procedures and results. Chapter 7 summarizes the findings of three rounds of user studies, including the limitation and future works.

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Chapter 2 Literature review

2.1 Human robot interaction in various fields

HHRC has become an important field over the past two decades, where humanoid robots have been widely used in various fields, such as education, medical and finance.

Educational robots

Education-related robots usually act as an instructor or teaching assistant to enhance learning process. Prior study indicated that robots can effectively enhance students' learning behaviors (Westlund et al., 2016). For instance, a humanoid robot can use its expressive behaviors to tell stories for preschool students in a kindergarten (Conti et al., 2017), or its gestures to deliver the course materials in a more vivid way (deWit et al., 2018). To improve students' learning performance, an educational robot can not only guide the students to learn course contents (Ramachandran et al., 2018) but also recommend relevant information to supplement the deficiency (Lin et al., 2014) in course materials.

Medical robots

Most of the medical-related services developed in a humanoid robot are focusing on elderly care and patient companion, which can decrease the medical care provider's workload and enhance the overall service quality (Agrigoroaie &Tapus, 2016). For instance, a robot physician can conduct a medical interview (Edwards et al., 2017) to monitor the patients' health status; or act a as a rehabilitation assistance and use its

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human-like appearance to encourage the patients to engage in the exercises (Meghdari et al., 2017; Schrum et al., 2019).

Commercial robots

Commercial robots can be seen in a variety of fields, such as retail stores and transport hubs (airports, metro stations, etc.). For example, in a bank, a humanoid robot may greet customers, deliver flyers to introduce products, and check customers' information to satisfy their needs (Lan, 2016).

A variety of robotic applications are available to fulfill various kinds of users' needs. As shown in table 1, the humanoid robot (e.g., Pepper robot) has several physical functions (e.g., touch screen, gesture, voice) to interact with human users, which can introduce the financial products and display the information to the customers. However, as observed, users tend to interact with a robot via the physical elements (such as clicking a button on a tablet) rather than talking to the robot or using the robot's gesture features to activate the desired functions (Tonkin et al., 2018). This can be resulted from the developer's inappropriate design or user's insufficient knowledge of a robotic application. The lack of utilization of a humanoid robot's physical features may lead to suboptimal HHRC performance. To examine this issue, this study examined the current robotic services and explored the users' expectations of the potential robotic features.

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Table 1 Robotic applications in education, medical and commercial fields.

Field	**Context**	**Capability**	**Interaction**	**Findings**
Education	Storytelling (Conti et al., 2017)	Voice Gesture Eyes' color	The robot tells stories to the learners along with vivid behaviors.	Expressive robots are better at telling stories than static robot.
	Learning language (deWit et al., 2018)	Voice Gesture Adaptation Screen	The robot uses its voice functions to answer the users' requests.	Robot with gestures has positive effect on long-term memorization, and higher level of engagement.
	Checking library information (Lin et al., 2014)	Voice Screen Sensor scanner	The robot uses its voice functions to introduce the library facilities and book information.	Robot provided robotic assistance to find library resources.
Medical	Rehabilitation (Schrum et al., 2019)	Voice Gesture sensor	The humanoid robot uses its voice and gesture to guide the patients to do the exercise.	Robot is an effective to encourage dementia patients to exercise.
	Medical interview (Edwards et al., 2017)	Voice Gesture	The patients talk to the robot doctor and answer the health-related questions.	In medical condition, the robot is not as effective as humans.
	Medical questionnaire	Voice	The robot uses its voice functions to	Robot provide medical

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	(Lin, 2018)		collect the patient's health information.	information and make the medical interview more efficient.
Commercial	Product information (Satake et al., 2015), (Lan, 2016)	Voice Gesture Printer	Customers can approach the robot to get a flyer and check product information. The robot will use its voice and gesture functions to deliver the requested information.	visitors indicated that the robot provide useful service, and wanted to use it in future.
	Airport guidance (Tonkin et al., 2018)	Voice Screen Motion	Visitors first talk to the humanoid robot and then the robot shows the directions to the gate/store.	Customers have positive user experience by the robot interaction.

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2.2 Robot personality

The big five personality traits are the most widely used in human robot interaction. Extraversion, Agreeableness, Conscientiousness, Openness, and Neuroticism (Table 2) can be used to represent the robot personality (Meerbeek et al., 2009; Vinciarelli &Mohammadi, 2014).

Table 2 Big-Five model

Dimensions	**traits**
Extraversion	tendency to be energetic, outgoing, positive, etc
Agreeableness	tendency to be kind, trusting, compliant sympathetic, etc.
Conscientiousness	tendency to be efficient, organized, reliable, striving, etc.
Openness	tendency to be curious, imaginative, fantastic, artistics, etc.
Neuroticism	tendency to be anxious, tense, unstable, depressed, etc.

Prior research concluded that extraversion and introversion are the most popular and widely examined personality traits (Robert, 2018). Studies also indicated that extraversion dimension of the Big Five personality traits is more accurately judged than other dimensions (Lippa &Dietz, 2000). Humans can observe the personality via nonverbal communication in a short time.

Extrovert is more energetic, social, and communicative(Robert, 2018). In contrast, introvert is quiet and restrained. Ambivert was defined as person who are not an

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extrovert and not an introvert(Cohen &Schmidt, 1979; Meerbeek et al., 2009; Vinciarelli &Mohammadi, 2014). In the past studies, most of the studies have explored the influence of extroverted or introverted robots in human robot interaction. However, the ambiverts were rarely been studied. This research had designed the robotic application and explored the influence of different personality traits (introverted vs. neutral vs. extroverted).

Recent studies have used robot personality to investigate people's preferences of robot personality. The study reveals that the majority of children tend to prefer the extrovert robot compare to introvert robot (Jewell et al., 2019). In addition, humans might prefer robots with similar personality. The study examined the relationship between human personality and robot personality (Andrist et al., 2015). The interaction with the similar personality robot increases the motivation to finish a repetitive task. Using appropriate personality traits to design the robot may encourage the participants to use the library service.

2.3 Non-verbal communication

Non-verbal communication includes gaze, gesture, and proximity (Chidambaram et al., 2012). The importance of gestures was reported (B. G. W.Craenen et al., 2018).

A large amount of previous research has investigated the effects of verbal and non-verbal cues on human robot interaction. Previous study indicated that participants' have higher compliance with a robot's suggestions when the robot uses nonverbal cues to communicate with the participants (Chidambaram et al., 2012), in which the robot

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conveys suggestions via its gaze to enhance the participants' engagements. However, when both verbal cues and non-verbal implements are adopted in the human robot interaction, it is difficult for humans to notice the uses of non-verbal cues (Jewell et al., 2019).

Therefore, in this study we referred non-verbal cues to as implicit cues. To deploy the robot in the library, we focus on developing a librarian robot with implicit cues.

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Chapter 3 Methodology

To examine the effects of robot personality, three rounds of user study were included. First, the user study focused on investigating the potential expectations of humanoid robots and find the important robot features. Second, the user study focused on identifying the requirements of librarians. We obtained implication of the design to develop a robot librarian. Int the third-round study, we focused on the implementation of a robot service for library and investigated the readers' acceptance of different personality robotic applications. Figure 1 shows the research framework.

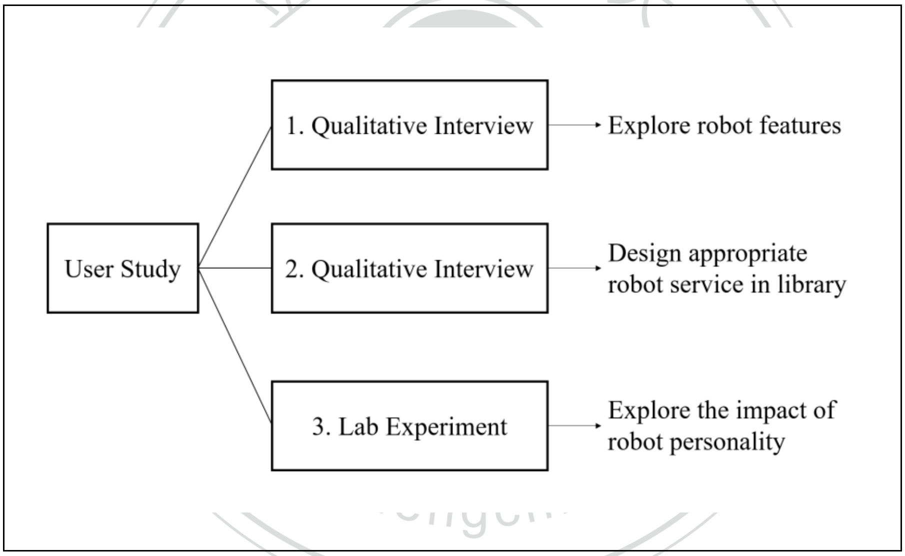

Figure 1 Research framework

The folk model approach was adopted in the qualitative interviews to explore robot features. Lab experiment in this research examines a variety of factors, including robot personality (Introvert vs. Ambivert vs. Extrovert) and robot features (Text vs. Text and Gesture) to provide the library guidance. Details of the user studies will be included in chapter 4, 5 and 6, respectively.

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Chapter 4 First Round User Study

4.1 Participants

Three student participants were recruited and interviewed to collect their opinions on the robot usages in various contexts. To increase the diversity and get a better picture of users' general attitudes in a robotic agent, all the participants have different majors and expertise. In addition, to avoid respondent fatigue, each participant was randomly assigned with two of the three experimental scenarios (Table 1), the experiment took around an hour to complete.

4.2 Procedure

Inspired by Wash's folk model study (Wash, 2010), the first round user study adopted the folk model method to investigate the general public's understanding of humanoid robots. Several semi-structured interviews were conducted to explore user's preferences of social service robots, in which the participants were asked to answer the interview questions by drawing HHRC processes. The think aloud approach was used along with participants' drawings and annotations to fully explore and collect their opinions. The interview questions can be found in Appendix A.

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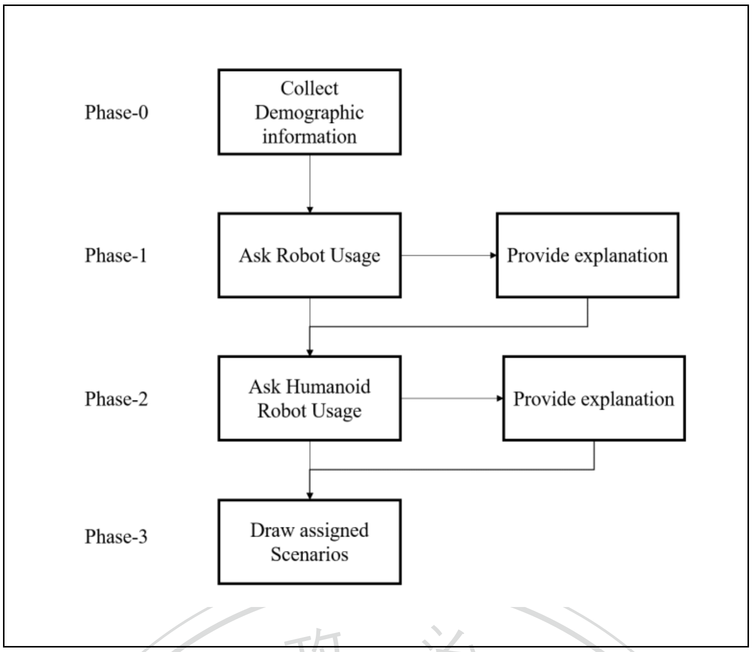

Figure 2 Experimental procedures

The interview procedure included the following steps (Figure 2):

- **Phase-0:** Demographic information collection.

The participants first filled up their demographic information, such as age and gender.

- **Phase-1:** Questions about the general uses of robots.

The participants would answer several questions regarding their general picture of a robot (e.g., do you know what a robot is? or have you ever interacted with a robot?). If the participant had interacted with a robot before, the participant would be asked to draw the interaction processes to reveal his/her purpose of using the robot and his/her overall experience of the interaction. However, if the participants have little understanding of robots, they would be provided with the definition of robot (Yao et al., 2019).

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- **Phase-2:** Questions about humanoid robot usages.

The participants were asked to provide their understanding of humanoid robots (questions such as “Can you explain what a humanoid robot is? or What is the uniqueness of humanoid robots”). This line of questions was aimed to discover if the participants were able to distinguish between robots and humanoid robots.

- **Phase-3:** Scenarios and drawing.

Three scenarios were introduced to the participants (Table 3) and they were asked how they may use humanoid robots in these scenarios. In each scenario, the participants were asked to specify the services that a humanoid robot could provide and then draw the interaction processes and provide the appropriate annotations to depict the situations. These scenarios were frequently discussed and were therefore adopted in this study.

Table 3 Scenarios in the first round interview

	Location	Descriptions
1st scenario	Hospital	Humanoid robots can provide reception services in hospitals as well as guide patients to the waiting room. In addition, robots can lead patients to do the rehabilitation exercises which can contribute to better health recovery.
2nd scenario	Bank	Humanoid robots can greet customers and introduce financial products to them. Meanwhile, customers may be waiting for human agents to finalize their transaction services, robots can provide interactive games to entertain customers and enhance overall user experience.

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3rd scenario	School	Humanoid robots act as teaching assistants to practice English conversations with students as well as correct students' pronunciation.

4.3 Results

The results of Phase-1 revealed that all of the participants have a certain level of understanding regarding robots. The results showed participants are most familiar with sweeping robots or pet robots, rather than humanoid robots. In fact, the participants have no prior experience in interacting with humanoid robots (discovered in phase-2). They only had read or heard news about humanoid robots on media.

User's expectations of humanoid robots' applications

As the participants have little experience in humanoid robots, the experimenter provided relevant information to the participants, which allowed them to have better ideas of potential applications of humanoid robots. Based on the assigned scenarios (Table 3), the participants drew potential and expected interactions with humanoid robots and provided annotations of the interactions. For instance, a participant expected the robots can assist customers in checking bank account details or applying for a credit card (figure 3). In the credit card scenario, a robot can help verify the application requirements by scanning a customer's financial information (bankbook). If the application is approved, the robot can raise its arms to celebrate with the customer and display the credit limit on the screen.

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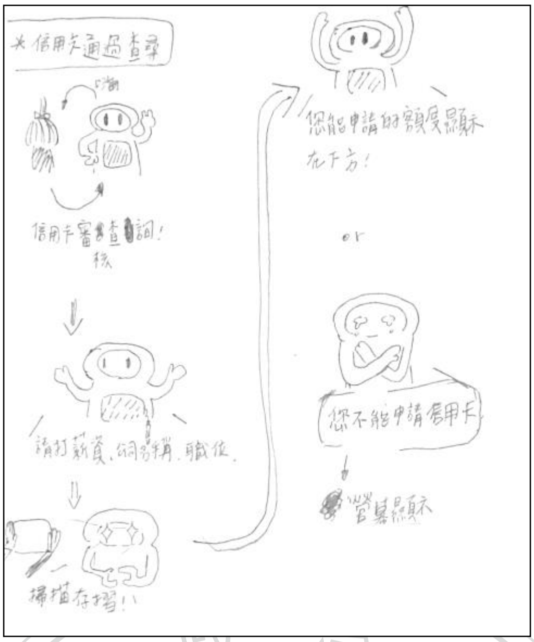

Figure 3. The drawing depicts the steps in an interaction process between human and robot. An example of the financial services provided by a humanoid robot from a participant's designs.

According to the participants' forethoughts, humanoid robots' features can be identified into four categories:

- **Voice**: robots can orally communicate to users
- **Gesture**: robots can use physical features (e.g., arms, fingers, etc.) to convey meaningful messages to users
- **Movement**: robots are able to move around and guide users to their desired places
- **Emotion**: robots may use facial expression to interact with users

We further investigated the participants' perceptions towards these features. The results are summarized in table 4. In general, the participants reported that humanoid robots should include voice and gesture functions which suggested these functions are

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essential to future humanoid robots. In other words, the voice and gesture features are equally important for a humanoid robot to provide appropriate services.

Table 4 Experimental Conditions

Scenario: M refers to Medical; F refers to Finance; E refers to Education.

ID	**Scenario**	**Voice**	**Gesture**	**Movement**	**Emotion**
P1	M&F	x	x		x
P2	M&E	x	x	x	x
P3	F&E	x	x	x	

Gaps between users' expectations and current humanoid robots' applications

In addition to the financial services mentioned above, various types of services were reported by the participants, such as product recommendation, behavior monitoring (figure 4a), and patient companion (figure 4b). For instance, in figure 4a, the participants designed a robot that can supervise students' learning activities (e.g., writing homework). If the robot finds out that the student is not paying enough attention to the learning materials, the robot would switch to anger mode (e.g., The robot may present angry face or expresses negative emotions) and warn the student. In figure 4b, the participant designed a robot to accompany child patients. The robot would use its tablet to display pictures or show videos to tell stories and play music to entertain the children.

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(4a) (4b)

Figure 4 Parts of Participants' drawings for illustrating the humanoid robot's functionalities.

Some of the functionalities mentioned in figure 4b are already developed in the real world. However, most of the features suggested by the participants are either underdevelopment or currently unavailable due to the technology limitation (such as figure 4a). The results revealed the gaps between users' expectations and current humanoid robots' applications.

4.4 Discussion

The participants did mention the importance of robot's physical features (e.g., gesture, human-like appearance, etc.), which could provide more efficient and friendly services than the conventional 2D information devices and contribute to better perceived intimacy. However, the use of a robotic services is still limited and 2D devices are more widely used. Therefore, it would be critical to explore users' expectations and humanoid robots' capabilities in order to develop applicable services.

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Chapter 5 Second Round User Study

The first round interviews discovered the voice and gesture are the essential components of a humanoid robot. As one of the research goals of this study is to develop a robot librarian, based on the first-round findings, we further identified how to develop the robotic applications to appropriately fulfill the librarians' needs as well as decrease their work loads. In addition, the experimental procedure was adjusted in the second round study to reduce the over expectations. For example, the participants were provided with some user stories and more details of the humanoid robot (e.g., show the real robot image).

5.1 Participants

Three librarians were recruited from a local university to participate in the interviews. Same as the first round interview, all three librarians have heard about robots, but never interacted with humanoid robots. The experiment also took about an hour to complete

5.2 Experiment Design and Procedures

Before the official experiment, the librarians were asked to report their what and how their daily tasks are and students' frequent difficulties in libraries (such as user needs, frequently asked questions, or current problems). This step was conducted to help us design experimental scenarios to be as lifelike as possible. The scenarios are mainly about students' possible experience within the library and how a humanoid robot can assist in the process, details are described in the following section. In the official

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experiment, the scenarios were presented to the participants (librarians) and they were asked to point out any potential issue.

Scenario1– International Students (IS)

- **(IS-Q1)** an exchange student wants to apply a library card to access the library services.
- **(IS-Q2)** an exchange student wants to borrow a library computer to work on his assignment.

Scenario 2– Domestic Students (DS)

- **(DS-Q1)** a domestic student forgot to bring his student ID card/ library card (Note: this question is a bit different from IS-Q1, as the student ID card and library card are integrated for the domestic student at local university. Therefore, a domestic student does not have to apply for a library card).
- **(DS-Q2)** a domestic student need direction guidance to the discussion room he reserved.

5.3 Results

From the second round interview, the librarians suggested that a humanoid robot can first focus on solving the readers' common requests (such as finding books or locating discussion rooms). After satisfying such common requests, the robots can provide the advanced services, such as promoting and assisting the readers to participate in library activities. Consequently, the usage of humanoid robots can decrease their work loads. As mentioned above, the participants believed robot librarians are capable to introduce

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the general settings (e.g., discussion room) to the readers. For example, if a student is searching for a discussion room, the robot is capable to guide the student to reach the reserved location. The drawings (such as figure 5a and 5b) revealed that the participants applied robot's voice function to deliver most of its services (e.g., introducing and explaining the library settings). However, the robot's gesture element is only used at the very beginning to attract users' attention (e.g., a robot librarian first waves its arms to greet the visitors and then use its hands to direct readers' attention). This implies that the participants believed voice and gesture can better address reader's requests and enhance the service quality. As the participants have little knowledge about how the robot's gestures may influence users' attitudes or behaviors, the participants' descriptions of the gesture element is insufficient.

(5a) (5b)

Figure 5 Librarian participants' drawings

5.4 Discussion

User adoption for a humanoid robot

The results revealed that there are still numerous deficiencies existed in current humanoid robot applications which might hinder robot service adoptions. For example,

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the participants mentioned a humanoid robot can be an assistant in the hospital (e.g., helping nurses to move patients or remind them to take medicine) and accompany child patients (e.g., storytelling, singing, and dancing). However, the participants also expected a robot to deliver the surgical procedures (e.g., tooth extraction) for child patients to provide better companions in the hospital. Likewise, library users expect they can retrieve relevant information from robots (e.g., find a book or facility instructions) but the guidance service is unavailable in most cases (e.g., introduce facilities). In addition, the librarian participants also mentioned that readers may still prefer to seek help from a librarian instead of interacting with a robot, which suggested that the importance of user acceptance in innovative technologies.

Implications for design the library robot

Our study results revealed that most of the participants believed voice and gesture functions (rather than gaze, eye-contact or mobility) are the fundamental and equally important elements of a humanoid robot. The lack of appropriate humanoid robot applications can be the major cause of the results. It is therefore important to further explore and examine the potentials of a humanoid robot and develop appropriate applications adapt to different contexts and their needs.

Although the voice function is one of the most commonly used features in the first round user study, this function can be inappropriate in a library, as it demands quiet reading. It is therefore critical to deliver the service via a robot's physical (gesture) features rather than voice applications. The librarian participants also suggested the gesture features can better fulfill this request. For example, while greeting multiple

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groups of visitors, the voice functions would affect the library readers, hence the gesture function would be a great fit in this context to provide a “quiet” and effective service.

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Chapter 6 Third Round User Study

Previous studies examined users' actual needs and expectations in order to explore potential opportunities to advance the humanoid robot's features. The results suggested that the robot gesture is one of the essential elements. The preliminary results identified the general users' experience of robot's applications as well as their expectations of the potential features that could be developed in the future. Based on these preliminary results, we focus on developing appropriate designs to satisfy users' needs in robotic applications and services in third round study. We develop a robot librarian in the third-round study to determine how the robot's features (gesture and texture) might impact user acceptance in innovative technologies.

This research aims to investigate the influence of robot personality in the quiet place. To develop appropriate design in library, this study adopted nonverbal features (text and gestures) to design the robots service. In this experiment, the robot's personality was expressed by text and gestures. we designed three types of robot (introvert vs. ambivert vs. extrovert), and conducted experiments through online questionnaires and lab experiment. The experimental procedures included the following steps (Figure 6):

- **Pilot test (text)**: to examine textual features.
- **Pilot test (gesture)**: to examine gestural features.
- **Pilot test (text and gesture)**: use non-verbal features (text and gesture) to develop its personality to confirm the robot design.
- **Lab experiment (text vs. text and gesture)**: explore the effect of different types of robot personality across numerous task contexts.

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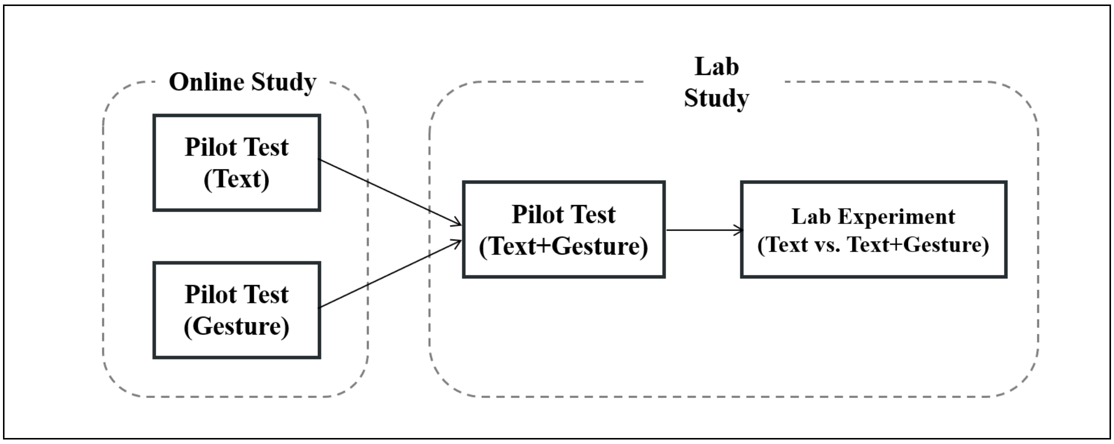

Figure 6 Experimental procedure

6.1 Pilot text (Text)

To ensure that the text on the robot tablet can effectively express the personality traits of the robot (introverted vs. neutral vs. extroverted), we designed three types of scripts, and conducted experiments through online questionnaires. The questions can be found in Appendix C. The experimental process is as follows:

- **Step-1:** Provide three system interfaces for the participants. The main content is a library tour (Figure 7), which introduces the facilities of the library with different type of personality characteristics.
- **Step-2:** After the participants read the introduction of the library, they had to judge the prototype's personality traits.
- **Step-3:** All the participants were asked to answer open questions to get their opinions.

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In the pilot experiment, we conducted three rounds of surveys for one month. After each round of questionnaire collection, if the recognition rate didn't above 80%, the prototypes will be adjusted until the robot's personality can be effectively distinguished.

According to (Okita et al., 2009), researcher use the framework to design the information of items, our library guidance content also divided into five parts : introduction, name, purpose, feature, and application(Figure 7). Based on the previous research (Fang-Yu Wen;Yu-Chen Hsu, 2005), the system interface designed to use in the formal experiment(Figure 8).

架構	導覽內容
介紹	您好，歡迎使用圖書館導覽服務。
名稱	預約書區包含智慧預約書架、預約書查詢機、預約書自助借書機與智慧還書箱，提供預約書查詢及借閱，您可以在服務櫃檯旁邊找到預約書區。
目的	達賢圖書館館藏全面採用RFID系統，讀者不需要至服務櫃台，也能自助借閱預約書。
特色	自動化系統能夠根據館藏地自動進行整理，商圖分館及達賢圖書館的書，系統可立即歸還，總圖、綜圖及傳圖仍須人工處理。
應用	如果您有預約書的需求，直接到預約書查詢機感應借書證，就能至智慧預約書架取書，並使用自助借書機完成取書的作業。

Figure 7 Prototype Framework

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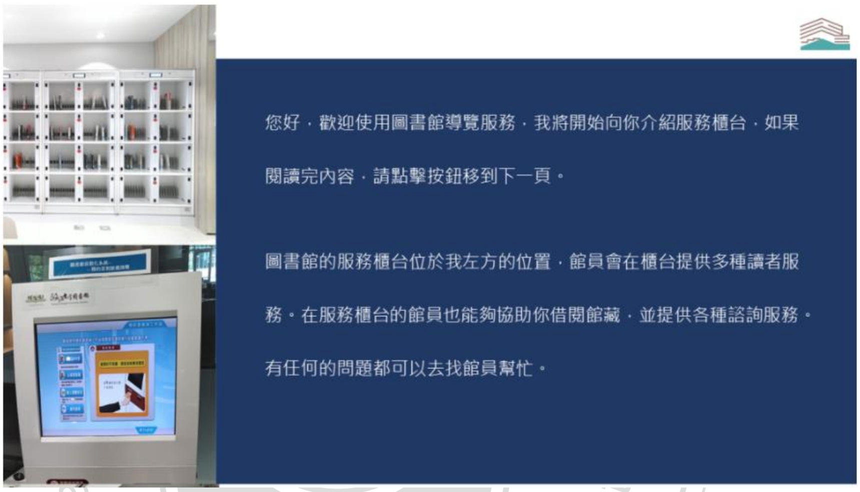
Introvert

Ambivert



Extrovert

Figure 8 Content design (Introvert vs. Ambivert vs. Extrovert)

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Results

Three rounds of pilot test were conducted to examine the text effect with 65 subjects (Figure 9). The results revealed that most of the participants can distinguish robot's personality (introvert: 85%, ambivert: 85%, extrovert: 100%). The participant said that "Introverts should be indifferent and should focus on content. In addition, the bullet point design makes me consider that is introverted. " The recognition rate of the three different personalities were over 80 percent. It represents that the general users can effectively distinguish robots with different personality traits in the current system design.

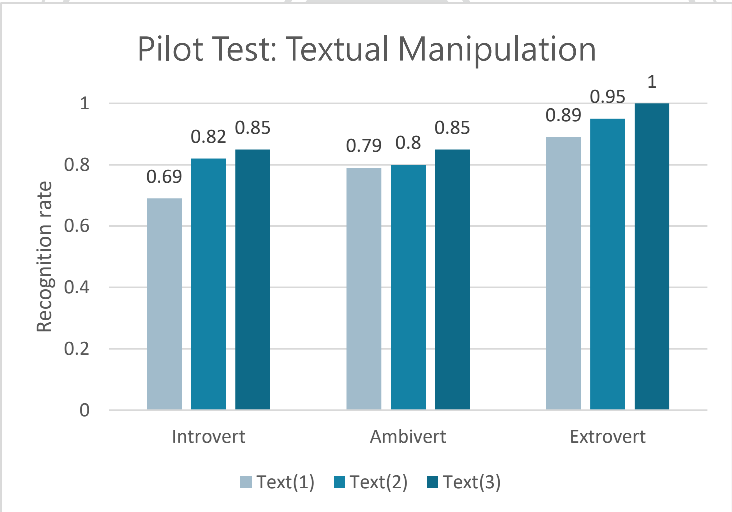

Figure 9 Textual Manipulation

6.2 Robot behavior design

This study used non-verbal cues (text and gesture) to manipulate the robot personality. The previous research indicate that extraverts have a more energetic behavioral than introverts (Ligthart et al., 2019; Martelaro et al., 2016). The extraverts talk faster and

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use fewer pauses. However, the verbal cues are not be used in our robot behavior design. Instead, the tablet of the Pepper robot is used to present the content to our participants. As previous studies (Richter &Salvendy, 1995), the tablet show more words and change the screen quickly.

The extravert robot use more gaze on the participant to represent the personality (Andrist et al., 2015). In our design the head movements of extravert robot are more than introvert robot. For instance, the robot switches their gaze between library facilities and the participants more frequently and quickly.

Furthermore, as previous studies (B.Craenen et al., 2018; B. G. W.Craenen et al., 2018), we manipulate body cues of the Pepper robot. The gestures of the extrovert robot are programmed to be more frequent than the introvert robot. The robot also show bigger movements when the robot present the content. The gestures are manipulated base on the original gesture in Pepper library.

6.3 Pilot text (Gesture)

We use amplitude, speed, and different types of gesture to design different personality of robot(B.Craenen et al., 2018; Ligthart et al., 2019; Tay et al., 2014). The Pepper robot (Figure 10) was used to record a 30 second video. The video showed the user try to use library guidance services. For example, the extroverted robot more energetic and move faster; introverted robots have small gestures and move slow; ambivert design is in the middle between the introvert and extrovert.

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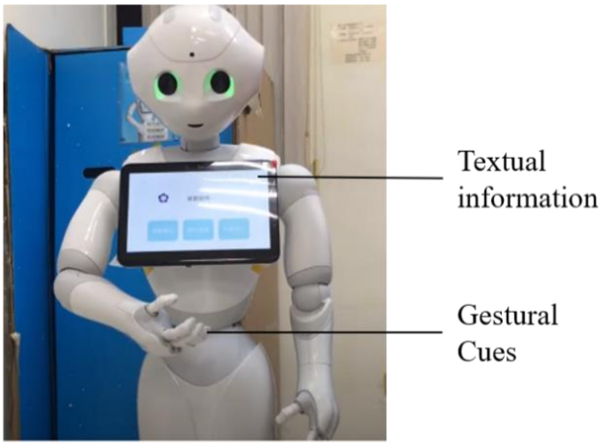

Figure 10 Pepper video

Questionnaire

In this pilot test, three robot personalities consisting of two variables (text and gesture) were developed. 165 participants were recruited to validate the prototypes. After watching the prototypes, the users were asked to answer the questionnaire to check robot personality (introvert vs. ambivert vs. extrovert). To avoid order effects, each participant was randomly assigned with three experimental scenarios. We also use open question ("How to evaluate the personality of the robot?") to collect user feedback and improve the system design.

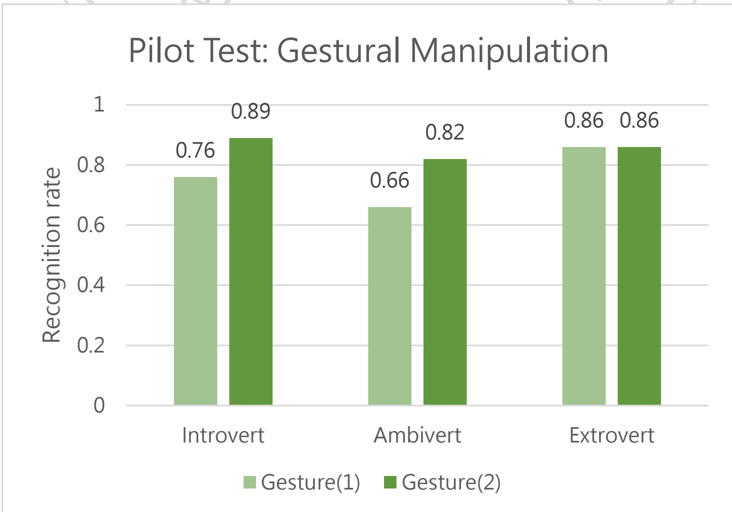

Figure 11 Gestural Manipulation

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The gesture pilot test is conducted in two rounds, recruiting 100 subjects, we had adjusted the speed of gestures to help the user to recognize the robot personality. The subjects were able to distinguish the robot personality successfully (introvert: 89%, ambivert:82%, extrovert: 86%). Participants said that "the speed of movement and the types of gestures" were the factors impact the participant to rate the robot personality. The results showed that their feedback is same as our system design. In addition, the subjects also mentioned that the robot moves faster, which makes people feel lively and extroverted, while slow speed is mild introverted. The results showed that robot gestures can successfully express the difference in personality traits.

Discussion

This study examines robot personality via nonverbal cues to improve the user experience and advance the humanoid robot applications in quiet area. The results suggested that the robot nonverbal features can help the users notice the difference between the three types of robots.

Based on these preliminary results, we designed a mixed study involving two variables: between the nonverbal cues (only text vs. text and gesture), and within the personalities of the humanoid robot (introvert vs. ambivert vs. extrovert). 40 students will be recruited and the Pepper robot will be used to provide library guidance services. The guidance tasks will be presented with different robot personalities and use different combinations of features to examine how the robot features might impact user acceptance in innovative technologies.

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6.4 Pilot text (Text and Gesture)

Before the formal task, a pilot test will be conducted to ensure the experimental manipulations (i.e., robot personality) are correctly designed and appropriately perceived and identified by the users. Five participants were recruited to rate the perceived extroversion/introversion of the robot personality to check the combination effect of text and gesture. Different types of robot personalities will be shown to the participant in a random order. All the participants interacted with the library robot and notice the personality difference.

6.5 Lab Experiment

The formal experimental process is as follows:

1. Each subject will use introverted or neutral or extroverted robots in random order.

2. After finish a task (use a library guidance), the participant will fill a questionnaire to measure the impact of the human robot interaction (such as robot personality(Lohse et al., 2008), trust, usefulness(Chien et al., 2014), interaction quality(Bartneck et al., 2009)).

3. Aa interview is conducted to receive the feedback from participants and explore the preference of personality in the task.

Participants

40 student participants will be recruited to complete this experiment from local university. Each participant will be randomly assigned to interact with either the

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extroverted or introverted robot. Every participant interacts with a robot with no gestures or gestural cues. The experiment will take approximately 50 minutes.

Between \ Within	Introvert	Ambivert	Extrovert
Text	1. Perceive the introduction of library facilities 2. Identify the robot personalities		
Text + Gesture			

Figure 12 Mix design

Materials and set-up

A Pepper robot (SoftBank Robotics) is used for developing a robot librarian (Figure13). All the robot commands are executed on the robot to simulate robot personality (extrovert robot and introverted robot). The experiment will take place in the lab to collect the empirical data. During the interaction the participants will be asked to finish three task and interact with three types of robots.

Figure 13 Pepper provide information to the participant

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Experiment Design

In second round study, librarians mentioned that the robot can help them do the daily task. The previous results revealed that participants believed the robot usage can effectively decrease their workload. The robot can automatically address their problems that can be a great help to librarians. Based on the feedback collected in the first and second rounds, we design the robot functions as follows.

The experimental robot consisted of five functions

- **Greeting**: The robot greets the participant and asks the participant to choose a service. For example, Pepper use cheering gesture to attract the participants and show the library service on its touch screen.
- **Search resource**: The participants use facial recognition to login and provide books information.
- **Recommendation**: Based on the search query or user profile, the robot will recommend books to the reader.
- **Guidance**: The robot introduces the library facilities. For example, Pepper uses its gesture to indicate a copy machine's location and shows the relevant information on the tablet.
- **Operating instruction**: The robot presents the instructions for operating a machine to the participants.

We choose guidance as the task of this experiment, the participants had to read the introduction provided by the humanoid robot.

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In our study an important factor is non-verbal behavior. By interviewing with the librarians specific the functions mentioned above were able to be applied in library. In this user study, the Pepper would be placed in the lab where the robot could stand and provide library information to the readers. An example is provided in Table 5.

Table 5 Example of a behavior in lab study

Behavior	Login Information
Screen	The pepper robot shows introduction to the participants and provide the option to the participants.
Head movement	The Pepper robot moves slightly and look at the participants during interaction.
Gesture	The Pepper robot uses cheering gestures to express emotions. Pepper uses talking movements when conveying information.

The experiment examines how implicit cues influence the interaction. The personality of the robots (introvert and extrovert) is designed and implemented in robot librarian. All the interactions that are included in the experiment were used to evaluate the design of the robots.

Before the experiment, the participants were asked to fill the personality questionnaire. We will briefly introduce the robot functions and procedure and ask the participants interact with the Pepper robot. When the participant terminates the interaction, the robot thanks and instructs them to fill questionnaire on the tablet.

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6.6 Measures

Questionnaire

To evaluate our experiment, three questionnaires with 5-point Likert scale are used and analyzed the users' feedback after interacting with the robot. The questionnaire is shown in appendix B.

- **Personality**: (Wiggins, 1979) is used to measure participants' personality. These items consist of introvert and extrovert items.
- **Intention to use**: This questionnaire is used to evaluate user acceptance of robot(Ajzen, 2002).
- **Godspeed Questionnaire**: The Godspeed score (Bartneck et al., 2009). was used for questionnaire. This is one of the most widely used questionnaires in Human robot interaction.
- **Trust** : Attitude toward the robot was measured by Universal Trust in Automation Instrument (Chien et al., 2014). These items were measured on a 5-point Likert-type scale.
- **Usefulness** : This questionnaire is used to evaluate the experience (Yim et al., 2017).

Interviews

- **Perceived robot personality and Preference:** We conducted an interview after the user study. The participant can see the robot guidance to answer the robot personality and preference.
- How did the participant identify the robot personality?
- What is the participant's preference?

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6.7 Results

There are six types of robot design were used by participants. Each participant has three post questionnaires. We apply SPSS software to perform the data analysis. Section 4.1 describes the background information of participants. Section 4.2 presents the recognition rate to answer the research questions. Section 4.3 shows the statistical result of measurements.

6.7.1 Demographic information

A total of 40 participants, aged between 18 and 55 (M=24.07, SD=8.51) participated in this experiment. The number of female and male participants were 23 and 17. All the participants were students from National Chengchi University. Among the participants, 21 participants had computer science background (Management Information Systems or Computer Science).

All of the participants revealed that they had seen humanoid robots before and 6 participants previously interacted with them. Most of the participants had no experience with robotic service. To sum up, most participants in this user study were not familiar to the robots. The Participants' demographic information are showed in table 6.

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Table 6 Participants' demographic information.

Variables	Category	N	Percentage (%)
Gender	Female	23	57.5
	Male	17	42.5
Age	18-20	13	32.5
	21-25	23	57.5
	Above 26	4	10
Educational background	Information Science	21	52.5
	Other	19	47.5
Have experience with robots	Yes	6	15
	No	34	85
Have been to library	Yes	37	92.5
	No	3	7.5
Library familiarization	1	4	10
	2	7	17.5
	3	18	45
	4	9	22.5
	5	2	5

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6.7.2 Participant Personality

Based on the average personality score, participants were classified into three types of personality traits (Introvert vs. Ambivert vs. Extrovert). Ambiverts are defined as people who are in the middle between introverts and extraverts (Cohen &Schmidt, 1979). Therefore, participants who scored between 2.5 and 3.5 on personality score were classified ambivert.

(1) Introvert participants: Participants who scored below 2.5 on personality score were classified introvert.

(2) Ambivert participants: Participants who scored between 2.5 and 3.5 on personality score were classified introvert.

(3) Extrovert participants: Participants who scored above 3.5 on personality score were classified introvert

All of the participants were asked to finish the personality questionnaire. Table 7 presents the experimental data on participant's personality. 4 participants were classified as introvert personality, 23 participants were classified as ambivert personality and 13 participants were extroverts. The results indicate that ambivert is the most common personality type in this study.

Table 7 Participants' personality

Variables	**Category**	**N**	**Percentage (%)**
Personality	Introvert	4	10
	Ambivert	23	57.5
	Extrovert	13	32.5

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6.7.3 Perceived Robot Personality

1. Questionnaire

Each participant was randomly assigned with three types of robot (introvert vs. ambivert vs. extrovert) and different robot features (text vs. text and gesture). After each task, we asked the participants to rate the robot personality. Table 8 and 9 show the recognition rate on perceived robot personality.

Table 8 Recognition rate (Text)

Variables	Category	N	Percentage (%)
Personality	Introvert	20	45
	Ambivert	20	55
	Extrovert	20	30

Table 9 Recognition rate (Text+Gesture)

Variables	Category	N	Percentage (%)
Personality	Introvert	20	20
	Ambivert	20	60
	Extrovert	20	60

Interestingly, there were some differences in introvert and extrovert condition. Data from table 9 can be compared with the data in table 8 which shows people can distinguish the personality traits more effectively in extrovert robot condition. If the introverted robot have gesture, they will not be considered as introverted traits.

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2. Interview

The participants were interviewed to collect their opinions on the robot personality. After three experiment, we asked the participants to answer the robot personality. Table 10 and 11 shows the experimental data on perceived robot personality.

Table 10 Recognition rate (Text)

Variables	Category	N	Percentage (%)
Personality	Introvert	20	70
	Ambivert	20	75
	Extrovert	20	75

As Table 11 shows, the results revealed that most of the participants can distinguish robot's personality (introvert: 70%, ambivert: 75%, extrovert: 75%) in textual condition. The participant found some difference on content. The participant indicated that "Introverts should be indifferent and Extroverts should be friendlier and more interactive. I found the difference from the description." The recognition rate of the three different personalities were over 70 percent. It represents that the users can still recognize robots with different personality traits in lab experiment.

Table 11 Recognition rate (Text and Gesture)

Variables	Category	N	Percentage (%)
Personality	Introvert	20	90
	Ambivert	20	75
	Extrovert	20	95

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From this data, we can see that condition (text and gesture) resulted in the higher rate of recognition. The subjects were able to distinguish the robot personality successfully (introvert: 90%, ambivert:75%, extrovert: 95%). Participants said that “the extroverted robot’s movement is greater than others”, it was suggested that the body movement and gestures can shape the robot personality successfully.

Data from this table can be compared with the data in table 10 which shows people can distinguish the personality traits more effectively in introvert robot and extrovert robot condition. The majority of participants indicates with the statement that the robot without gesture just like a computer, they focus on the content on the tablet, so the participants didn’t mention the difference of robot personality.

6.7.4 User experience

To analysis the data the robot features and personality classified into six types.

Table 12 Robot types

Type	Feature	Personality
T-I	Text	Introvert
T-A	Text	Ambivert
T-E	Text	Extrovert
TG-I	Text+Gesture	Introvert
TG-A	Text+Gesture	Ambivert
TG-E	Text+Gesture	Extrovert

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In order to understand the differences in experience between various combinations, this study uses a questionnaire filled out by each subject after interacting with the robot to analyze the variance. The results are shown in the table 13. A one-way ANOVA revealed that intention to use, animacy and likeability had difference between the gesture and texture design.

Table 13 User experience - Analysis of Variance

	SS	df	MS	F	Sig.
Intention to use	14.265	5	2.853	4.528	0.001
Animacy	9.525	5	1.905	3.162	0.01
Likeability	10.787	5	2.157	3.028	0.013
Anthropomorphism	6.119	5	1.224	1.748	0.129
Perceived Intelligence	0.631	5	0.126	0.139	0.983
Perceived Safety	0.939	5	0.188	0.777	0.568
Trust	3.381	5	0.676	1.234	0.298
Usefulness	4.63	5	0.926	1.319	0.261

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Intention to use

Table 14 Descriptive of intention to use

		N	Mean	Std. Deviation	Std. Error
Intention to use	T-I	20	2.975	0.85801	0.19186
	T-A	20	2.975	1.05413	0.23571
	T-E	20	3.025	1.0788	0.24123
	TG-I	20	3.5125	0.51603	0.11539
	TG-A	20	3.775	0.51873	0.11599
	TG-E	20	3.7	0.48395	0.10822
	Total	120	3.3271	0.8506	0.07765

Table 15 Multiple Comparisons (Intention to use)

Dependent Variable	Scenario		Mean Difference	Std. Error	Sig.
Intention to use	TG-A	T-I	.80000*	0.25102	0.028
		T-A	.80000*	0.25102	0.028
		T-E	0.75	0.25102	0.052
		TG-I	0.2625	0.25102	1
		TG-E	0.075	0.25102	1

Post-hoc analysis was conducted with a Bonferroni correction. The results, as shown in table 15, indicate that there is significance between TG-A (Text+Gesture – Extrovert), T-I(Text – Introvert), T-A (Text – Ambivert) and T-E (Text – Extrovert). In summary, these results show that robot with gesture would make user want to use more and gestures had a strong effect on ambivert robots.

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Animacy

Table 16 Descriptive of Animacy

		N	Mean	Std. Deviation	Std. Error
Intention to use	T-I	20	2.5835	.89284	.19965
	T-A	20	2.4580	.85745	.19173
	T-E	20	2.6415	.88154	.19712
	TG-I	20	2.9245	.60878	.13613
	TG-A	20	3.1080	.65820	.14718
	TG-E	20	3.2245	.70814	.15834
	Total	120	2.8233	.81068	.07400

Table 17 Multiple Comparisons (Animacy)

Dependent Variable	Scenario		Mean Difference	Std. Error	Sig.
Intention to use	TG-E	T-I	.64100	.24545	.153
		T-A	.76650*	.24545	.034
		T-E	.58300	.24545	.288
		TG-I	.30000	.24545	1.000
		TG-A	.11650	.24545	1.000

Post-hoc analysis was conducted with a Bonferroni correction. The results, as shown in table 17, indicate that there is significance between TG-E (Text+ Gesture – Extrovert) and T-A(Text – Ambivert). Extrovert robot with gesture have the highest mean scores(M=3.2245). These results show that extrovert robot with gesture is most lively.

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Likeability

Table 18 Descriptive of Likeability

		N	Mean	Std. Deviation	Std. Error
Intention to use	T-I	20	3.280	1.1096	.2481
	T-A	20	3.080	.8907	.1992
	T-E	20	3.430	1.0687	.2390
	TG-I	20	3.760	.6508	.1455
	TG-A	20	3.880	.5672	.1268
	TG-E	20	3.830	.6027	.1348
	Total	120	3.543	.8793	.0803

Table 19 Multiple Comparisons (Likeability)

Dependent Variable	Scenario		Mean Difference	Std. Error	Sig.
Likeability	TG-A	T-I	.6000	.2669	.398
		T-A	.8000	.2669	.050
		T-E	.4500	.2669	1.000
		TG-I	.1200	.2669	1.000
		TG-E	.0500	.2669	1.000

Post-hoc analysis was conducted with a Bonferroni correction. The results, as shown in Table 19, indicate that there is significance between TG-A (Text+Gesture – Ambivert) and T-A (Text- Ambivert). These results suggested that ambivert robot with gesture would make user to have more Likeability.

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Performance

To ensure that all the participants can understand the information from librarian robot, our participants were asked to fill the questionnaire related to library facilities in each task. There were three questions in this section, participants can get one point for each correct answer. For example, If the user had one wrong answer, then 2 points will be awarded.

Table 20 Robotic applications in education, medical and commercial fields.

Robot Types	T-I	T-A	T-E	TG-I	TG-A	TG-E	Total
Score	2.35	2.55	2.7	2.55	2.5	2.6	2.54
N	20	20	20	20	20	20	120

No significant differences were found between the robot types (p value=.729>0.05). However, we found that in the case of Type 3 (M=2.7) is higher than others by the average. Interestingly, the Type 3 scores (Text - Extrovert) better than the conditions with gestures.

Preference difference

The table below illustrates the robot preference in the third round user study. None of these differences were statistically significant. But, there are differences in preference to a certain robot personality. Ambivert and extrovert participants prefer to use similar robot personality in the future. In summary, these results show that the similar attraction observed in ambivert and extrovert robots.

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When we asked whether they would like to use the service in the future, most of participant (55%) likely to use the extroverted robot. The participants point out that extrovert robot provide additional information and content with more gestures, so the extrovert robot considered to be more enthusiastic and friendlier. The participants also did mention the importance of the robot's physical features, which could provide more efficient services than the conventional 2D information devices and contribute to better perceived intimacy.

Table 21 Preference to robot personality

	Robot personality	Personality	Mean	Standard deviation
Intention to use	Introvert	Introvert	2.375	0.968246
		Ambivert	3.347826	0.577707
		Extrovert	3.326923	0.837808
	Ambivert	Introvert	2.5	1.47196
		Ambivert	3.554348	0.730646
		Extrovert	3.326923	0.937553
	Extrovert	Introvert	2.5	1.06066
		Ambivert	3.456522	0.748681
		Extrovert	3.461538	1.004397

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Chapter 7 Conclusion

7.1 Summary

Prior research suggested humanoid robots can be used in various fields and can greatly enhance the perceived service quality as well as user experience. However, as most of the existed robotic applications fail to utilize robot's features and focus mainly on its voice and gesture capabilities, first round study aims to examine users' actual needs and expectations in order to explore the potential opportunities to advance the humanoid robot's features. The results suggested that robot gesture function is the essential element to deliver the services.

In second round study, the results identified the general users' actual usages of robotic applications as well as their expectations of the potential features that could be developed in the future. Bases on these preliminary results, we developed the appropriate designs to satisfy users' needs in implementing the robot librarian.

To explore the effect of robot personality and non-verbal features. The goal of third round study is to examine the effect of the different robot personality design. We developed different types of robot to examine gesture features. The participants were able to distinguish the robot personality successfully in the lab experiment, the uses of multichannel non-verbal cues can strengthen the perceived robot personality and user experience.

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7.2 Implications

This study uses nonverbal cues to explore the influence of different robot design on the user's perception. The results revealed that participants can realized the differences between introvert, ambivert, and extrovert robots. The results in this research provide implications for developing an appropriate robot design in library.

The effect of gestures

The results of this study revealed that the recognition rate in gestural condition is better than textual condition. There were some suggestions that our participant interact with no gesture robots mentioned that the robot looks like a computer or pad. These results suggest that the gesture is an importance feature in human robot interaction.

User expectation

In this study, most of the participants have not used robots before, so they will look forward more interactions in this task, such as hoping that the robot will introduce them with voice, or hoping that the robot can have more gestures in the textual condition.

Likeability and intention to use

Likeability and intention were found significant difference between robot feature (gesture). There is a significant difference in the ambivert design, but there is no significant difference between introvert robot and extrovert robot, which means that the

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two personality traits of introversion and extroversion are not easily affected by whether the robot use gestures.

Given these findings, robot service can follow these design and framework to develop the application in different context. For example, businesses can use specific robot personality design to improve user's acceptance to use the new technologies. They would follow these approaches to attract more users to use the service. Therefore, we recommend to take the framework and robot features in this study to provide information to the user.

Prior research revealed that a humanoid robot can provide better services than the conventional (2D) information systems. This study reports an advantage in the impact of the humanoid robot usage that gesture features can effectively strengthen the uniqueness and impression of a robot as well as characterize its perceived personality. Furthermore, how to appropriately apply the non-verbal cues to shape a robot personality was uncertain. This study design introvert, ambivert and extrovert personality to explore the influence in human robot interaction. This study has reported an advantage in the robot personality that participant might tends to use similar personality robot.

7.3 Research Limitation and Future Research

Several limitations arise when applying the robot personality in this study. First, the results from the online questionnaire and the lab study were consistent in third round study. Our participants can distinguish the personality difference. But, there is not find

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significant difference on similar attraction in this study. Although there is not sufficient evidence for the similarity attraction, we found that participant would prefer an extroverted robot as library guide.

Second, this study only selected university students as the participants that our sample is not diversified that the users came from same age groups. Therefore, the representativeness of the participant may not be enough. To further examine the impact of these robot design on general public, future work can consider recruiting different age groups to analyze the user experience.

Third, the participants were asked to interact with the robot service by viewing the library guidance. The task might too easy that participants spend less time interacting with the robot and the robot function didn’t meet the user’s expectations. In future work, we plan to conduct a high complexity task to further examine human robot interaction issues across numerous task contexts.

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Appendix A

Interview questions (First round study)

Personal Information Collection

- Please introduce yourself (gender, age, and department)

Usage of robots

- Did you use a robot? Please explain what is robot.
- Did you use a humanoid robot? Please explain what is humanoid robot.
- What is the difference between a humanoid robot and a kiosk?
- What is the main function of a robot? What is the most important part of a robot?

Scenarios

- In the scenarios (hospital / school / bank), what are the uses of robot? (4-5 items)
- Please explain the interact processes.
- Please draw the human robot interaction in various fields.
- How can robots improve service quality?

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Appendix B

Questionnaire (Third round study)

Demographic information

What is your gender
What is your age
Have you interacted with humanoid robots (such as Nao, Pepper)
Have you been to Library
Library familiarization

Personality

Introverted	Undemonstrative
	Shy
	Unrevealing
	Unsparkling
Extraverted	Outgoing
	Vivacious
	Enthusiastic
	Cheerful

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Intention to use

I will look forward to use the library robot service
If I need assistance, I will consider using a library robot
Using library robots is my best choice
I would recommend others to use the library robot

Interaction quality

Anthropomorphism	Fake-Natural
	Machinelike-Humanlike
	Unconscious-Conscious
	Artificial-Lifelike
	Moving rigidly-Moving elegantly
Animacy	Dead-Alive
	Stagnant-Lively
	Mechanical-Organic
	Artificial-Lifelike
	Inert-Interactive
	Apathetic-Responsive
Likeability	Dislike-Like
	Unfriendly-Friendly
	Unkind-Kind
	Unpleasant-Pleasant
	Awful-Nice
Perceived Intelligence	Incompetent-Competent
	Ignorant-Knowledgeable
	Irresponsible-Responsible
	Unintelligent-Intelligent

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	Foolish-Sensible
Perceived Safety	Anxious-Relaxed
	Agitated-Calm
	Quiescent-Surprised

Trust

Librarian robot improves my performance.
Librarian robot enables me to accomplish tasks more quickly.
My interaction with librarian robot is clearly understandable.
Librarian robot is user-friendly.
Librarian robot uses appropriate methods to reach decisions.
I am confident about the performance of librarian robot.
When an emergent issue or problem arises, I would feel comfortable depending on the information provided by librarian robot.

Media usefulness

Librarian robot enhances my ability to learn the library information more effectively.
Using the librarian robot saves me time.
Librarian robot enables me to acquire information more quickly.
Overall, I find the librarian robot useful in my experience.

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Appendix C

手勢1

手勢2

手勢3

機器人手勢(每個選項僅可使用一次) *

	內向	中性	外向
手勢1	○	○	○
手勢2	○	○	○
手勢3	○	○	○

請說明您是如何判斷機器人性格? *

您的回答

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