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Design Exploration on Robots to Support Single Women at Home in China

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***Abstract*— The widespread adoption of home robots shows a high demand for in-home assistance. Since single women account for a large proportion of the Chinese population, it is important to design home robots to support their lives at home. This study aims to explore the possible design features of home robots to support single women in China. Interviews and an online survey were used to gauge user perception and expectations of home robots. Our research reveals the unique lifestyle preferences of single women in China and how home robots could be designed to support their needs. We discuss our findings and design implications based on three aspects: lifestyle, intelligence, and sense, to inspire better robot design for women.**

I. Introduction

With the rapid development of artificial intelligence, robots have been widely adopted by people in home environments. Different from industrial robots that perform repetitive tasks in factories and stores, home robots are expected to play important social roles. Specifically, social robots are designed to work in different contexts such as home, hospitals, museums, and airports to fulfill diverse needs. For instance, smart home assistants such as Amazon Echo are responsible for controlling smart home devices, whereas home service robots such as Roomba are designed to clean floors. Therefore, home robots should be designed variously to fulfill the needs from different users.

Recently, the number of single women rises quickly worldwide [8], [16], [18], [25]. Previous research has reported that women account for the majority of the population that live alone. There are 17 million women and 14 million men in the US who live alone [8]. In pre-modern society, it is rarer to stay single and live outside of the conventional family structure. Individual needs and desires could only be met if they were compatible with the common goals of the community [18]. Marriage was a priority for women to provide individual economic safety and biological reproduction. However, the structure of the society has changed in the post-modern society. Women have become more educated and financially independent, and marriage is no longer economically necessary for women. Although traditional Chinese culture dictates that women should get married early and be housewives, modern day Chinese women are increasingly participating in the workforce and are less dependent on having a partner. Among the single women in China, more than 36% choose not to get married in and 36.8% of them feel happy being single in 2015 [15]. Based on the report of Ministry of Civil Affairs of the People's Republic of China in 2016, there are 11.4 million couples who got married in 2016, and the marriage rate dropped by 6.7% compared to 2015; there are 4.2 million couples divorced in 2016, and the divorce rate rose 8.3% compared to 2015 [35]. Moreover, it is reported that Chinese single women have the greatest contribution to the GDP in China compared to other countries [5].

As Chinese single women become a core contributor for the Chinese economy, it is meaningful to care about their lives and improve their well-beings. Therefore, there is potential to design home robots for single women to improve their lives. Many existing studies have been conducted on home robot design for a specific population, such as older adults [7], [20], [32], [37] and children [3], [21]. However, few studies [26], [32] have been conducted to design robots for young adults such as Chinese single women. As staying at home is a way of decompressing from overconnected social culture [8], home robots for single women should be designed to support decompression at home. As user acceptance is a key factor to robot design [32], designing home robots for Chinese single women requires understanding how they perceive and expect on home robots. This paper aims at exploring the perceptions and expectations on home robots of single women in China. We also propose design implications towards home robot design to support Chinese single women who live alone.

II. Study Design

This study contributes to research on the design of home robots to support Chinese single women at home. Our study used personal interviews along with an online survey, to gauge single women's lives at home after work as well as their preferences and perceptions toward different types of home robots.

A. Participants

Our study involved 10 female participants in China. The participants were recruited on researchers' social media and related online forums. To focus on user needs in a home environment, we only recruited single female participants who spent more time at home than going out after work. Our participants age from 22 to 29, which is the main population of single women in China. Though most participants are students, we have other participants working at the government, financial companies, IT companies, etc. Detailed demographics are presented in Table I.

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TABLE I. DEMOGRAPHICS OF PARTICIPANTS

	Participant Demographics	
	Age	***Occupation***
P1	22	Graduate student
P2	23	Financial advisor
P3	29	Graduate student
P4	23	Graduate student
P5	24	Graduate student
P6	26	Government officer
P7	27	Data analyst
P8	29	Government officer
P9	24	Media planner
P10	27	Financial analyst

B. Methods

We conducted semi-structured interviews with participants. Each interview lasted about one hour. All interviews were conducted in Chinese online, and the interview audios were transcribed into English texts by the researchers for further analysis. In our interview, each participant was asked questions about their lives after work at home such as what they usually do after work at home and what made them comfortable staying at home. In order to get more insights about participants' interests and demands, we showed each participant some images of activities people usually do outside such as shopping, exercise, singing, etc., and asked each participant what activities they would like to do at home. Then we showed each participant an online survey in Chinese to fill out.

In our survey, we asked participants to evaluate four existing static smart home devices in four sections: 1) *general evaluation (feelings, usefulness, intelligence, manner, friendliness)*; 2) *lifelikeness evaluation (machine, human, animal, plant, toy)*; 3) *social role preference (assistant, servant/maid, romantic partner, close friend, pet, teacher, idol, tool)*; and 4) *interaction preference (voice control, visual cues, gestures, touch, bodily movement, smart control)*. We only pick static smart devices because we want to focus our evaluation on social intelligence. The evaluation of static smart home devices would evaluate more on the social intelligence systems inside the devices. Robots with embodiment and locomotion could be evaluated in future studies. Specifically, we asked participants to rank the social roles we provided under the social role preference section, and we used a five-point Likert scale to evaluate other sections. Our questions were developed based on previous work on robot design and user acceptance [6], [14], [30], [32]. Smart home devices presented in the survey were Google Home, Mi AI, Gatebox and HoloEra (See Fig. 1). Google Home is a series of smart speakers and home assistants developed by Google. Mi AI (Chinese as 小爱同学) is a smart speaker developed by Xiaomi (Chinese as 小米) in China. Gatebox is a virtual home robot developed by Gatebox lab in Japan. HoloEra (Chinese as 琥珀虚颜) is a virtual home robot developed by Gowild (Chinese as 狗尾草) in China. Specifically, both Google Home and Mi AI are implemented as voice-activated assistants, so they do not have any images or virtual characters displayed on the devices. Both Gatebox and HoloEra are avatar-based, namely, they have human-like virtual characters inside the devices using hologram technology. All four smart home devices provide basic functions of voice conversation, smart home control, speaker, etc. As we want to show participants the embodiment of these devices and how they work in a real context, we pick the videos of these devices for participants, showing their operation and basic movements in a neutral context. Each video lasts about two minutes. Prompts to evaluate the devices were accompanied by links to videos online, and non-Chinese videos were subtitled in Chinese for participants to understand.

Figure 1. Smart home devices presented in questionnaire (from left to right): Google Home, Mi AI, Gatebox and HoloEra.

C. Interview Data Analysis

We applied open coding to the translated transcripts. The authors discussed the initial codes together. Chinese culture was considered during the coding process to identify the data more accurately. We then used affinity diagram to organize the open codes and iteratively refined emerged themes.

III. FINDINGS AND DISCUSSIONS

Based on our analysis of affinity diagram and survey results, we first describe our participants' general attitudes towards the smart home devices presented in our survey, then mainly identify and discuss the three key aspects to home robot design for single women in China: living style, intelligence, and sense.

TABLE II. GENERAL EVALUATION OF SMART HOME DEVICES

M/ SD	**General Evaluation of Smart Home Devices**				
	Feeling	***Usefulness***	***Intelligence***	***Manner***	***Friendliness***
Google Home	3.78/ 1.28	**4.00/ 1.04**	**4.33/ 0.80**	**4.0/ 0.83**	3.89/ 1.20
Mi AI	3.56/ 1.28	3.89/ 0.83	3.44/ 0.50	3.33/ 0.64	3.67/ 1.11
Gatebox	**4.44/ 1.14**	3.56/ 1.49	**4.44/ 1.37**	**4.78/ 0.66**	**4.67/ 0.67**
HoloEra	3.56/ 1.35	3.22/ 1.18	3.56/ 1.10	3.78/ 0.90	**4.00/ 1.04**

A. General Evaluation

We asked participants to evaluate the four smart home devices from five perspectives: feeling, usefulness, intelligence, manner and friendliness. Participants could choose from 1-5 (1: lowest, 5: highest). Table II shows the detailed results of the evaluation. Specifically, Gatebox ranks top regarding feeling, intelligence, manner, and friendliness, and Google Home ranks top for usefulness. Noticeably, both Gatebox and HoloEra have higher scores than Google Home and Mi AI on friendliness. As we mentioned previously, both HoloEra and Gatebox are based on human avatars, which implies the possibility of home robots with human avatars are more likely to be perceived as friends to users. It is an interesting topic for future research.

B. Living Style

Our interview results indicate that our participants share similar social features in their lives, which form a unique lifestyle for single women in China.

Prefer Personal Space: Based on our analysis, most participants prefer their own spaces, which is the main reason they prefer staying at home after work. Private spaces make them feel relaxed and comfortable, which is consistent with the finding of previous research [8].

> *P1: "Private space at home makes me relaxed, and I feel comfortable at home because I can do whatever I want."*
>
> *P4: "I prefer to read novels and stories at home than going out."*
>
> *P6: "I like staying at home alone because it is relaxing and free, and home makes me relax in spirit and body."*
>
> *P9: "I would like to stay in my room, I prefer a personal private space."*

Social Independence: Besides the private places, our participants showed their special social style which is social independence. Social independence here refers to minimal social activities after work, and don't want to bother other people.

> *P1: "I don't want to bother other people. I prefer to sing alone at one-person Karaoke room. Therefore, I don't want the robot talk to me too much in order to get close to me."*
>
> *P2: "I don't want the robot to talk too much. I want personal space even with robot. I hope it could care the feelings of other people."*
>
> *P5: "I don't want the robot to pretend it knows me well when we first meet."*

Above lifestyles are likely resulted from the culture of hyperconnection, or overconnection of social life today. Klinenberg [8] said in his book that since we were overconnected, living alone is one way to get a kind of restorative solitude, and our home could be an oasis from the constant chatter and overwhelming stimulation of the digital urban existence.

Based on the social features above, when designing home robots for Chinese single women, the conversation and social features should be reduced to satisfy the specific social style of Chinese single women. For example, the initial conversation could be set as minimal social interaction, and then increase incrementally as the robots get closer to their owners.

C. Intelligence

Home robots as artificial intelligence products should provide users intelligent supports in diverse aspects. Based on our analysis, we here mainly discuss the intelligence in functional and emotional aspect.

Functional Intelligence: Our participants showed their expectations of the functions a home robot could provide. According to the survey of social role preference, assistant, servant/maid, teacher, and close friend are ranked top among our participants for similar reasons. Participants select assistant mainly because they want to get information from robots and expect the robots to help with their work; participants select servant/maid mainly because they want the robots to do housework such as cleaning and cooking for them; participants select teacher mainly because they want the robots to teach and supervise them.

> *P2: "I expect robots to provide all kinds of knowledges to me, just as a teacher."*
>
> *P4, P9, P10: "I want robots to do cleaning, cooking, and housework."*
>
> *P5: "I want the robot to evaluate my skills and create study plan for me."*
>
> *P6: "I expect the robot to solve problems for me, provide information to me and do housework."*
>
> *P8: "I want the robot to provide me suggestions, help me make decision, and supervise me to be organized."*

Emotional Companionship: Our participants showed their demands on emotional companionship from the home robots. They expect the home robots to provide emotional support to them:

> *P1: "I need the robot to care about my feelings instead of keeping talking by themselves."*
>
> *P3: "The reason I like the character is that he makes me feel he cares about me and takes care of me."*
>
> *P7: "I want to feel that I am protected."*

Specifically, some participants want the home robots to provide the emotional support by playing certain social roles:

P4: "I expect the robot to be like Javis in Ironman. It should be like friend and close to me."

P6: "I want the role of the robot to be my boyfriend, because I expect it to provide emotional companion to me."

P10: "I want the robot to be my family member."

The interview results above show that our participants expect the home robots to provide proper emotional supports. This support is not based on voice activation but through a more intelligent way. Current home robots mainly use voice command to activate the robots, which is a passive conversation between users and robots. To enable more emotional conversations, other interactions such as movement, visual cognition should be added to the home robots.

D. Sense

Interaction: Our participants showed their preferences on the interaction with home robots (see Table III). From the table we could see that voice control and gesture are core methods the participants prefer to use in human-robot interaction. It is understandable that voice control and gestures are efficient and effective interaction methods that have been broadly utilized by current robots. Noticeably, touch is also preferred by most participants. As P5 mentioned in the interview: "*I prefer it to have physical entities because touching is also important to emotional resonance."* Future home robot design could consider touching as a new interaction method for Chinese single women.

TABLE III. INTERACTION PREFERENCES

Interaction Methods	Frequency
Voice Control	10
Gestures	7
Touch	6
Bodily Movement	5
Smart Control	5
Visual Cues	2

Voice: Half of the participants showed their preferences on the voices of the home robots after watching the videos. Participants prefer the voices to be more emotional and human-like, which echoes some previous research [9]. Specifically, P1, P5, and P6 showed their negative attitudes towards the mechanical voice of robots, because it made them feel the conversation between users and robots was preset. P4 mentioned that the conversation of HoloEra was embarrassing because the voice was machine-like. P1 and P6 mentioned that the tones and the voice of Gatebox were so cute that they wanted to possess one in their homes. Specifically, P4 and P7 even expressed the importance of voices for them when choosing a game to play.

P4: "I choose to play certain games because of the character voices in the games."

P7: "Voices matter a lot for me when I choose a game to play."

Specifically, our survey data also implies the importance of voice to user perceptions. In Table IV, we could see that participants perceive Google Home and Mi AI more as a machine, whereas participants perceive Gatebox more as human. It is understandable that the physical cylinder appearances of Google Home and Mi AI give participants the impression of a machine. However, although the human avatars inside the devices might make these devices more human-like, the differences between Gatebox and HoloEra show the possibility of voice as an important factor in people's perception towards the human.

TABLE IV. THE LIFELIKENESS EVALUATION

M/SD	Lifelikeness of Robots				
	Machine	***Human***	***Animal***	***Plant***	***Toy***
Google Home	**4.11**/ 0.60	3.11/ 1.22	1.67/ 0.66	1.33/ 0.46	2.33/ 1.33
Mi AI	**4.33/ 0.8**	2.44/ 1.11	1.44/ 0.49	1.67/ 0.92	2.44/ 1.20
Gatebox	2.44/ 1.00	**4.00/ 0.94**	2.44/ 1.10	1.78/ 0.78	3.11/ 1.08
HoloEra	3.00/ 1.25	3.11/ 0.83	2.00/ 0.83	1.78/ 0.78	3.22/ 1.10

Therefore, future home robot design should focus on providing more human-like voices, especially with different tones and emotions to enable people's perception of humans on robots.

Safety and Security: In our study, many participants showed their concerns about safety and security of home robots. They expressed their demands on controlling robots and protecting their privacy.

P1: "I don't want to be monitored by a robot.."

P2: "I don't want to share my daily routine with the robots, but I want to record it in physical schedule book."

P5: "I feel scared if a robot knows all my schedules.."

P6: "I want to have strong control over robots because I want the robot to be safe. For example, if there's something wrong with the robot, I should be capable to shut it down immediately."

Future home robot design should pay more attention to user control. Users should have a wide range of options for robot control. For example, users should enable and disable the robots freely, and have the customization on what information will be recorded and shared with the home robots.

Humanoid/Anthropomorphism: Participants showed various attitudes towards a humanoid home robot. Specifically, participants showed both positive and negative

attitudes about it. Some participants expressed their favors on humanoid robots:

> *P1: "I like humanoid robot because it can provide emotional companion."*
>
> *P2: "I prefer the robot to be humanoid so that I could treat it as a human."*
>
> *P6: "I like humanoid robots because I don't see many differences between home robots and smart phone assistants like Siri.. Then why do we need the robot?"*

The concept of "uncanny valley" has shown that people will have negative attitudes towards humanoid robots. Some of our participants showed their negative attitudes towards humanoid robots:

> *P3: "I don't want the robot to have humanoid look, but I still want it to understand my needs."*
>
> *P4: "I think humanoid robot is creepy."*
>
> *P5: "I don't like humanoid because I would like to communicate with real people. Robots are not human, why we make it as humanoid?"*

Based on our interviews, there is no specific answer to if the home robots should be humanoid or not. The user acceptance of humanoid home robots might depend on personalities and life experiences of users. Therefore, further studies should focus on this topic. Noticeably, in the context of home robots being humanoid, there are some aspects raised by our participants that we should consider heavily in the robot design process: 1) to what degree should humanoid go; 2) how to avoid the gender stereotypes in robot design.

> *P8: "Humanoid is cute, however, too much humanoid is only for certain people like Otaku…"*
>
> *P2: "I feel offensive when seeing all the humanoid robots use female maids as their virtual images."*

P8's thought implies that the discourses about the appearance of home robots, even the general robots, are not about simple binaries like humanoid and no humanoid but about considering in different contexts and to different degrees. Thus, we could have future research on how much humanoid we should put into home robots in the context of supporting Chinese single women at home.

Besides humanoid, designing with gender stereotypes is also a concern for participants. Stereotypes usually emerge as a way in response to environmental factors, such as different social roles and group conflicts and differences [1], [34], and in response to a need for social identity [28]. Gender stereotypes are the most pervasive stereotypes that appear in mass media, which provide distorted representation of women and minorities [23], [36]. Previous research has found that women are underrepresented and usually perceived as subordinate, passive, and dependent to men, and are portrayed in traditionally feminine roles such as nonprofessionals and homemakers in video games [11], [19], [24], [38], newspapers/books [22], [27], [31], and televisions [12], [13], [29], [33]. Exposure to these distorted images can have a negative effect on users' perception of women. Previous research has found that robots with gender stereotypes could provide social cues that might trigger user responses in human-robot interaction [2], [4], [10]. However, little research [4], [17] has focused on the humanoid design in a gender-stereotyped context. Therefore, future home robot design should not only consider how gender stereotypes help with the human-robot interaction but also how gender stereotypes might reinforce people's stereotyped perceptions of gender, especially for women.

Embodiment: Our participants showed their diverse opinions on robot embodiment as well:

> *P6: "I prefer embodied robot not virtual characters."*
>
> *P4: "People who change their minds all the time demands on robots with dynamic appearances, which embodied robots can't accomplish…"*
>
> *P9: "I would like robots with virtual characters of my idols, but not embodied…"*

Similar to the humanoid feature, the preference on human avatars and embodiment in our study heavily depends on the personal perceptions and experiences of participants. Further research is needed to dig much deeper into this topic.

E. Other Findings

Our study also finds some interesting insights about home robot design. Specifically, P3 said, *"I don't want any smart home robot because the installation is troublesome."* It implies that designers should design the installation and guidance of the home robots to be simple and easy to understand. Additionally, P8 said, *"Sometimes it's more fun to find the answers myself."* Designers could consider evolving the traditional Q&A conversation to a lively and freedom interaction. Thus, users might feel the robots less machine-like due to the preset conversation.

IV. CONCLUSION

This paper mainly explored the perception and preference of home robots of single women in China. Based on our study, we find that single women in China who spent more spare time at home have their unique lifestyle. They enjoy staying alone at home and prefer an independent social interaction. To improve their living qualities at home, current home robot design should consider social interaction, intelligence, and sense during the design process. There are some limitations in this work. First, since there's no specific definition for robots, we only showed two types of static smart home devices to participants, which might limit participants' imaginations on what a home robot could be. Therefore, future studies could show participants with more robots with different size, appearance and moving ability. Second, we have a limited number of participants, which is insufficient to represent the single women in China or to generalize the findings from the study. Specifically, for survey data, the differences on home

robots might not be significant. However, since our participants share similar living patterns, their views still provide insights for home robot design. The findings of this study could be used as start points of further research. For example, the results are diverse about whether home robots should be humanoid, embodied, or virtualized in our study, so future work could focus on how humanoid of home robots affect Chinese single women live at home, and what characters of Chinese single women relate to their preferences on enabled or virtualized humanoid home robots, by conducting user studies with more single women in China.

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